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COVER

The heath and woodland complex on the Maroota Sandmass, an ancient fluvial deposit of sands, gravels and clays of uncertain age, is restricted in the Sydney area, and inadequately conserved (see Ryan, Fisher and Schaeper, p. 433).

Cunninghamia

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Allan Cunningham

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The natural vegetation of the St Albans 1: 100 000 map sheet

Kate Ryan, Mark Fisher and Liza Schaeper

Ryan, Kate, Fisher, Mark and Schaeper, Liza (National Herbarium of New South Wales Royal Botanic Gardens, Sydney, Australia 2000) 1996. The natural vegetation of the St Albans 1: 100 000 map sheet. Cunninghamia *4(3): 433–482*. The composition and extent of the present natural vegetation on the St Albans 1: 100 000 map sheet 9031 (lat. 33°00'–33°30'S, long. 150°30'–151°00'E) are mapped and described in terms of structure and characteristic species. 14 map units covering 23 plant communities are recognised including tall open-forests, open-forests, woodlands and sedgelands. Vegetation patterns relate strongly to underlying geology with major groups of communities being restricted to shale (Wianamatta or Narrabeen Group), sandstone (Hawkesbury Sandstone) or alluvial (Quaternary) soils. Within these groups, patterns relate to rainfall gradients, sheltered or exposed sites, and soil drainage conditions.

Much of the map area is on rugged sandstone country and has now been protected in National Parks and State Recreation Areas but the better soils on the riverflats and on the shale and volcanic outcrops have mostly been cleared for agriculture. Plant communities and species on these soils have been most impacted by development and are most vulnerable. Comments are made on the adequacy of conservation reserves. 31 significant plant species are listed, 22 of which are nationally rare or endangered; others have regional significance.

Introduction

The St Albans 1: 100 000 map sheet covers an extensive area of the Triassic sandstone plateau country north of Windsor and northwest of Sydney. As part of the Sydney Region Vegetation Series, this paper describes and maps the natural vegetation of this area, much of which is national park and an important part of Sydney's conservation reserve system. The St Albans vegetation map shows the plant communities mapped in the same format as previously published maps in the Sydney Region Vegetation Map Series. These are the 1: 100 000 map sheets for Wallerawang (Benson & Keith 1990), Katoomba (Keith & Benson 1988), Penrith (Benson 1992), Gosford – Lake Macquarie (Benson 1986) and Burragorang (Fisher, Ryan & Lembit 1995), all published in the Royal Botanic Gardens ecological journal *Cunninghamia*.

The St Albans 1: 100 000 Vegetation Map Sheet is based on the St Albans 1: 100 000 Topographic Survey Sheet 9031 (AUSLIG, Canberra). The mapped area covers almost 2 530 km², or 253 000 ha, of the extensive sandstone plateau country north-west of Sydney. It extends from just north of Windsor and Richmond (latitude 33°30'S), to north of the Mellong Plateau (latitude 33°00'S) and from east of the Macdonald River (longitude 151°00'E) to west of the Colo River (longitude 150°30'E). The area is covered by the 1: 25 000 Topographic Survey Sheets Wirraba, Six Brothers, Colo Heights, Mountain Lagoon, Moruben, Auburn, St Albans and Lower Portland and falls within the Central Coast Botanical Subdivision of New South Wales. It includes parts of the local government areas of Hawkesbury, Hornsby, Baulkham Hills, Gosford, Cessnock and Singleton.

The map sheet area is part of the Hawkesbury–Nepean River catchment, a coastal drainage system bounded by the Great Dividing Range, the watershed between the eastern (coastal) and western (Murray–Darling) drainage systems. The Hawkesbury–Nepean catchment extends from the Hunter Range, some 130 km north-west of Sydney, south to Goulburn and includes the tributary rivers Colo, Macdonald, Capertee, Wolgan, Grose, Cox, Wingecarribee and Wollondilly. It meets the sea at Broken Bay, just south of Gosford.

A substantial part of the catchments of the Colo and Macdonald Rivers are included in the map sheet area which includes the Colo Plateau, between the Macdonald and Colo Rivers and part of the Hornsby Plateau, east of the Macdonald River. These rivers and their tributaries have cut deep V-shaped valleys into the Triassic Hawkesbury Sandstone, exposing the underlying geological strata of the Narrabeen Group, also of Triassic age. The general height of the Colo Plateau is 200–300 m on the eastern edge, rising to 600 m on the western edge. The Mellong Range, the main north–south ridge, separates the Colo and Macdonald flows. Branching off the Mellong Range to the west are smaller ranges, such as the Culoul, which end abruptly to form steep escarpments over the Colo River. The most spectacular of these are found in the Colo Gorge where the Hawkesbury Sandstone ends abruptly to form cliffs above the deeply entrenched Colo River. Branching off to the east of the Mellong Range are the Howes and Womerah Ranges which are drained by a maze of small tributaries of the Macdonald River. The channels of the Colo and Macdonald Rivers widen in their lower reaches before they join the Hawkesbury River in the south-eastern corner of the map sheet area.

Most of the land still retains its natural vegetation cover. Wollemi National Park, part of the largest wilderness area in New South Wales, covers the western third of the map sheet and Yengo National Park and Parr State Recreation Area (south of the Womerah Range) covers most of the eastern two-thirds. The boundary between Wollemi and Yengo, the Putty Road, is the main access to the area and follows the ridge of the Mellong Range. Agricultural development has generally been confined to the alluvial flats of the Macdonald, Hawkesbury and lower Colo Rivers and the occurrences of Wianamatta Shale.

Geology and geomorphology

The map sheet area occupies part of the Sydney Basin Triassic sandstone plateau (New South Wales Dept of Mines 1966). The upper layer, consisting of Hawkesbury Sandstone, the major outcropping rock of the Sydney Basin, the Mittagong Formation and the Wianamatta Group shales, is saucer-shaped and lies on top of layers of sandstone and other sediments of the Narrabeen Group. The rivers have cut down through the Hawkesbury Sandstone to expose the underlying Narrabeen sandstone especially in the northern and western parts of the map sheet area where the edge of the Hawkesbury Sandstone is approached, and the sandstone becomes thinner. Here Hawkesbury Sandstone is confined to the upper slopes and ridges while the Narrabeen Group dominates the slopes and gullies. The lithological characteristics of the two groups are different. The Hawkesbury group is predominantly coarse quartz sandstone with some small lenses of mudstone and siltstone. The Narrabeen Group has lithic conglomerate, quartz-lithic sandstone with lots of chunky lenses of red, green and grey shale (Herbert 1980).

On the Hawkesbury Sandstone the most extensive soils are grey- and yellow-brown uniform sands to sandy yellow leached gradational soils (Hamilton 1976). They are strongly acid and are characteristically deficient in phosphate and are often locally deficient in nitrogen (Herbert 1980). They also have a poor water-holding capacity. Shallow skeletal sands are common on the ridges, but in the gullies, sands may be metres deep, enriched by soil removed from upper slopes, silt and organic matter. Where the shaley Narrabeen sandstone has been exposed in the deeper gullies, eroded shales form deep clay-rich soils and these rich soils are accompanied by a change in

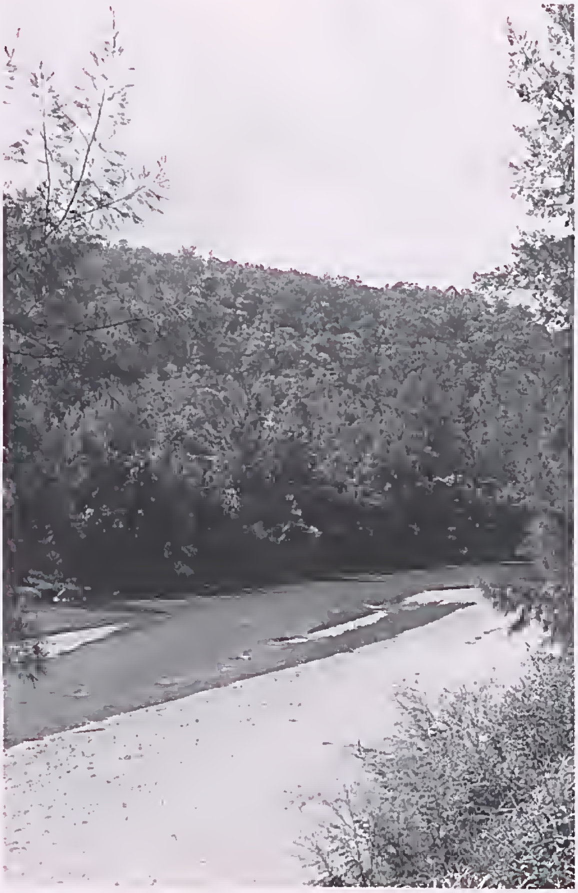

Fig. 1. River Oak, *Casuarina cunninghamiana*, is the characteristic riverside tree along permanently-flowing freshwater sections of the Colo and Hawkesbury Rivers.

vegetation (Sanders et al. 1988). Shale lenses occur in both the Hawkesbury and Narrabeen Groups; their soils typically have sandy topsoils overlying usually yellow clay subsoils (S. McInnes pers. comm.).

The Mittagong Formation (passage beds between the Hawkesbury Sandstone and the Wianamatta Group) is fine grained sandstone that forms sandy topsoils, overlying yellow clayey subsoils with stratified ironstone plates (S. McInnes pers. comm.).

The Wianamatta Group was the last stage in depositional development in the Triassic Period and overlies the Hawkesbury Sandstone; the Wianamatta Group is composed mostly of shale with only sporadic, thin lithic sandstones (Herbert 1980). Patches of Wianamatta Group shale occur on the peaks and higher ridges from Wheelbarrow Ridge, along the Mellong Range from Colo Heights up to Devils Hole. Smaller isolated

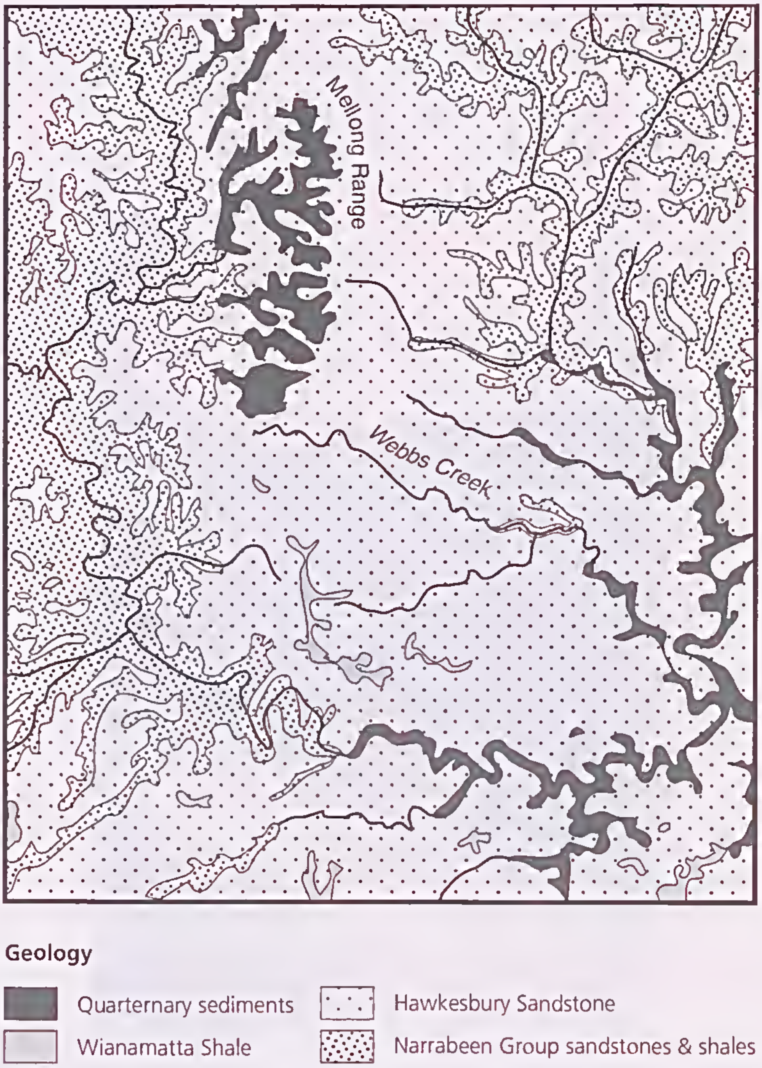

Fig. 2. Geology of the St Albans map sheet area (based on NSW Department of Mines 1966).

patches occur near Grassy Hill and along Culoul Range. Itchenstoke, in the south-west of the map sheet area, has another isolated patch. The Wianamatta Shales weather to clay loam texture-contrast or duplex soils. Soils derived from shales are reasonably good for agriculture and vegetation here has usually been cleared. This is especially noticable on air photos: the shale areas are generally isolated patches of cleared land surrounded by extensive sandstone vegetation.

Tertiary volcanic caps are relatively uncommon in the map sheet area. These are cappings of basalt that intruded through the sandstone and survive now as peaks, scattered throughout the sandstone ranges. Basalt caps weather to deep clay loams, rich in iron and magnesium (Hamilton 1976) and can be found on the higher peaks of Wirraba Range, Culoul Range, The Devils Hole and Mt Terraborra (on the Womerah Range).

An unusual sand deposit with a diverse and varied vegetation occurs at Maroota. Once covered by basalt and believed to be of Tertiary age but possibly as old as Jurassic or Cretaceous, the Maroota Sandmass is of fluvial origin and consists of interbedded quartz sand and gravels with some kaolinitic clay layers (Douglas 1996).

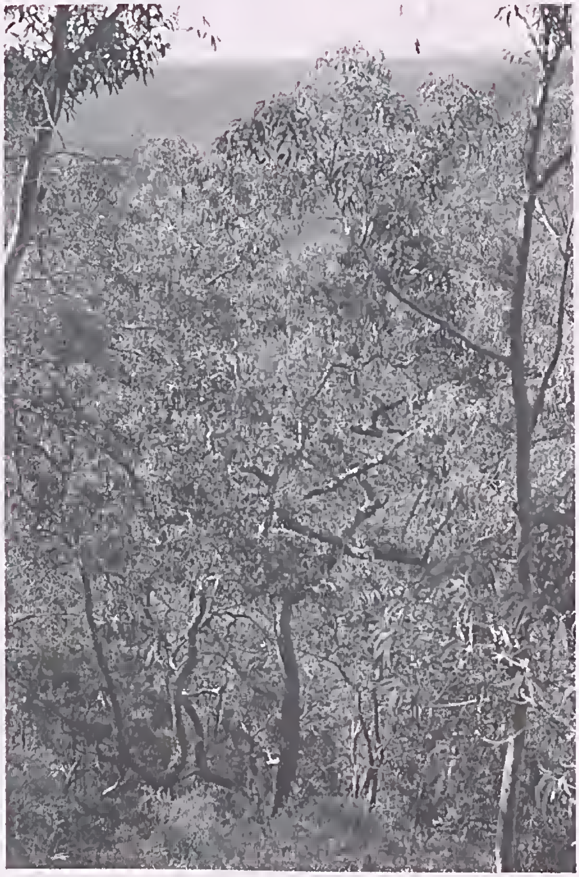

Fig. 3. Woodland with Yellow Bloodwood, *Corymbia eximia*, occurs widely on exposed ridgetops and upper slopes of the extensive sandstone plateaus that are characteristic of much of the map sheet area (Map Unit 10ar).

The Mellong Range plateau is 20 km long and 3 to 8 km wide and extends from the foot of the Culoul Range to south of Putty. Surrounded by dissected ridges and gullies of regional extent, the flatness of the Mellong Range plateau is anomalous; its wide, shallowly incised valleys; valley-side embayments; and westerly flowing transverse drainage are described by Henry (1987). In spite of its location on top of the Macdonald–Wollemi Creek drainage divide, the plateau is extensively alluviated, with large swamps occurring on all main creeks and tributaries. Quarternary alluvial sands occur in a series of shallow valleys towards the northern end of the Mellong Range and contrast markedly with the surrounding rugged sandstone country. Eight swamps each exceed 1 sq km in area but most swamps dry out at the surface after less than three months of drought. Henry (1987) reports little accumulation of peat but, at depths less than 1 m, sediments in swampy areas typically exhibit little or no organic staining. Well developed podsols are widespread in silty and clayey sand on flats and low slopes but are not found on all sites.

Dark loamy porous alluvial soils occur on Quaternary alluvium, along the floors and floodplains of lower reaches of the larger streams, the Macdonald, the lower Colo and the Hawkesbury Rivers. A period of sand-deposition also occurred this century, during the late 1940s and early 1950s, when east-central NSW experienced an unusually wet period and annual discharges of both the Hunter and Hawkesbury Rivers were highest in the historical records. Bank erosion, bench demolition and bed aggradation resulted in the transformation of the Macdonald River valley from an initially narrow V-shaped channel into a much wider channel with alluvial deposits (Henry 1977).

Climate

Wedged between the coastal ranges, and the Upper Blue Mountains and Great Dividing Range, the area covered by St Albans map sheet is mostly in rainshadow and is a relatively dry part of the Hawkesbury–Nepean catchment. Rainfall is generally 900 mm over the elevated region of the Mellong Range (e.g. at Colo Heights, Table 1, Fig. 4) (Bureau of Meteorology 1979), decreasing to 800 mm on the western side. The eastern (windward) side of the Mellong Range is also rather dry as it is situated behind the coastal ranges and averages 800–900 mm per annum (e.g. annual rainfall at Wisemans Ferry is 777 mm). The south-west of the map area, seated in front of Mount Wilson, experiences higher orographic rainfall and reaches 1300 mm per annum (e.g. Bilpin 1300 mm p.a.).

Average maximium temperature for January is 28°C. Average minimum temperature for July is 2–3°C.

Methods

This vegetation survey and map is based on information from earlier surveys together with aerial photography, satellite imagery, field checking and site-based data collection. It enlarges upon and updates a previous draft report *Explanatory notes for the St Albans 1: 100 000 Vegetation Map Sheet* (Benson 1980) and provisional maps (1980,

1986) and incorporates references to earlier vegetation surveys by other workers. The general vegetation of the Central Coast was described by Pidgeon (1937, 1938, 1940, 1941) and Forster et al. (1977). Detailed surveys of specific areas include the Mellong Plateau (Howard 1981), and the alluvial flats of the Hawkesbury River (Benson 1974, Benson & Howell 1993, Stricker & Wall 1995).

Most recently a comprehensive survey of the vegetation of Yengo National Park and Parr State Recreation Area was done for the NSW National Parks and Wildlife Service by Sanders et al. (1988) and added to by Webb & Bell (1992). The first survey involved the analysis of 120 sites, the recognition of 13 plant communities and vegetation mapping at scales of 1: 25 000, though the maps were not published. Bell et al. (1993) did further sampling, analysed a total of 236 sites, recognised 15 plant communities and produced vegetation maps at the 1: 25 000 scale for use in fire management. Their study area goes far beyond the St Albans 1: 100 000 map sheet area but their work was drawn on considerably for the upper and middle Macdonald valley where inaccessibility limited field work.

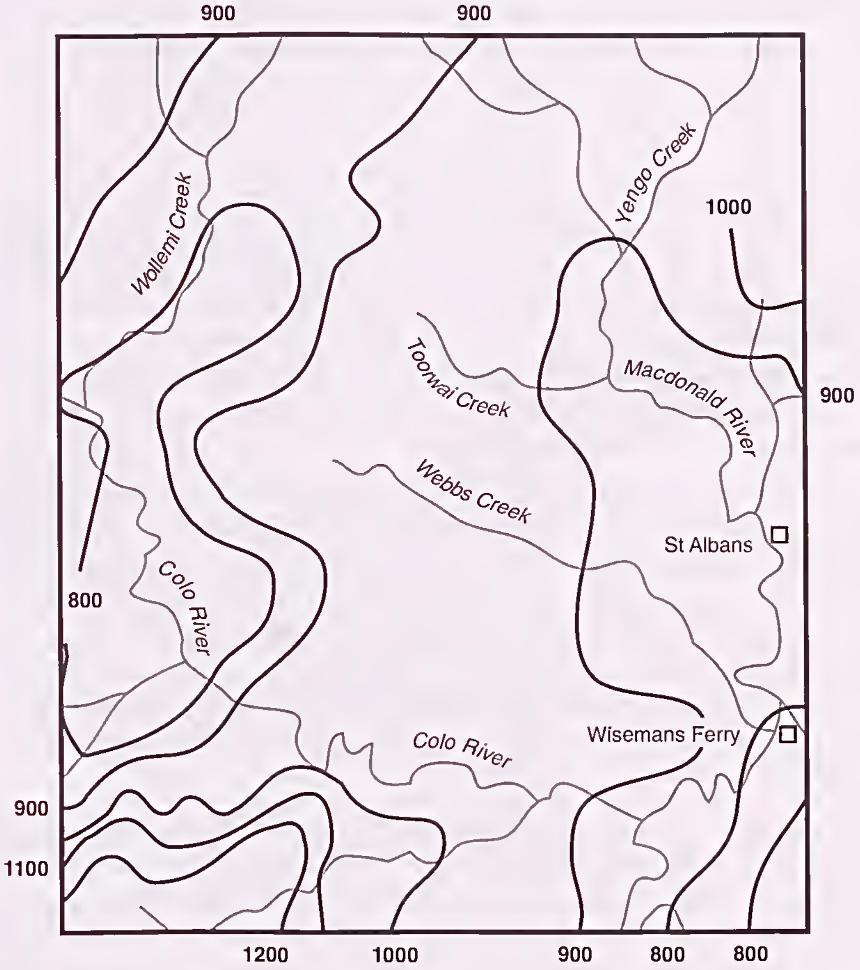

Fig. 4. Average annual rainfall isohyets (mm) for the St Albans map sheet area.

The map units derived from the extensive numerical analyses carried out during the National Parks and Wildlife Service surveys of Yengo National Park and Parr State Recreation Area (Sanders et al. 1988; Bell et al. 1993) and the vegetation maps for those surveys were adapted for the 1: 100 000 scale map presentation here by combining some units into subunits, where the original units could not be shown because of the limitation of mapping scale. In areas not covered by these surveys, particularly west of the Putty Road, additional sampling sites were selected within each of the recognised plant communities and then marked onto the air photos and topographic maps in preparation for field work.

Reconnaissance field work was carried out to identify the vegetation patterns and relation to geology and topography described in the earlier surveys and to extrapolate from the mapped areas of Yengo and Parr into adjacent unmapped areas. This allowed preparation for air-photo interpretation, wherein areas of vegetation with similar structure (Specht 1970) and floristics (dominant species) were grouped to form map units on the basis of photo-patterns from air photos and recognisable geological and landscape characteristics. Colour 1: 25 000 aerial photographs (1991) and LANDSAT TM imagery (1: 100 000, 1991) were used in combination with topographical, geological and soil maps to determine plant community boundaries. Particular criteria adopted in air photo interpretation included tree height, crown shape, size, density and cover. Sources of information used in the compilation of maps are listed in Table 2.

From September to November, 1994, sites were sampled and community boundaries checked and confirmed. Rugged topography and restricted access confined sampling to sites along roads and firetrails so that coverage of the map units is consequently uneven, with sheltered gully types being undersampled. Quadrats conformed to the standard Royal Botanic Gardens site-sampling, including a 20 m × 20 m quadrat, a list of all vascular plant species present within the sampling area, percentage cover of each species, the number and height of each strata, soil type, landform, geology and disturbance factors for every site. Data from these sites was incorporated into the community descriptions and species lists.

On the final vegetation map, an alphanumeric code is used to distinguish individual plant communities. The numeric code represents the structural form of the plant community and the alphabetic code refers to either the dominant species of the tallest stratum or the geological type which supports the community. Map units have also been provided with common names based loosely on habitat and composition, for ease of reference. The codes used are consistent throughout the Sydney Region 1: 100 000 Vegetation Map Series, allowing map units to be cross-referenced. Provisional vegetation maps were drafted at the 1: 25 000 scale and reduced to the scale of 1: 100 000.

The vegetation map is a diagrammatic attempt to simplify the distribution patterns of an often rich and varied flora, over an extensive region. The scale of the mapping and time constraints allow detailed treatment of the dominant canopy and main understorey species only. It is scale-dependent and map units will almost invariably include unmapped areas of other map units too small to be shown separately.

Similarly, most plant communities do not have clear-cut boundaries but grade into each other, often over a broad ecotone. For mapping purposes such boundaries have to be represented by a line.

There are a number of constraints in reducing the complex pattern of natural vegetation to a map format. The map units recognised are not all of equivalent rank. Some are essentially land units made up of several plant communities associated with a particular geological or physiographic type (e.g. map units 10ar and 10ag) whereas others are more clearly plant associations (*sensu* Beadle & Costin 1952) (eg. map units 6g and 10me). Generally the term 'plant community' is used for the basic vegetation unit.

Species lists for plant communities were compiled from our fieldwork together with relevant site data from the surveys of Sanders et al. 1988 and Bell et al. 1993, Howard (1981), Hind (pers. comm.). Lists of rare and endangered species were compiled from the national ROTAP listing maintained by the National Parks and Wildlife Service together with reference to specimens at the National Herbarium of New South Wales. Botanical names used are those currently recognised at the National Herbarium of New South Wales. For authorities see Harden (1990–93).

Table 1. Mean monthly and annual rainfall (mm) for four weather stations on the St Albans map sheet. (Source: Bureau of Meteorology 1979)

Location lat/long	J	F	M	A	M	J	J	A	S	O	N	D	Year
Bilpin 33°31'S, 150°29'E	151	170	146	112	88	105	76	69	68	84	101	130	1300
St Albans 33°20'S, 150°57'E	71	76	75	74	60	54	96	52	52	50	64	89	813
Wisemans Ferry 33°23'S, 150°59'E	76	88	82	65	64	68	74	42	43	50	55	70	777
Colo Heights 33°23'S, 150°45'E	47	55	163	27	57	51	35	254	18	130	50	90	978

Table 2. Sources of data used in preparation of St Albans 1: 100 000 vegetation sheet.

Source	Year	Information	Scale
NSW Dept of Lands	1991	Colour aerial photographs	1: 25 000
Soil Conservation Service of NSW	1985	Soil maps for Hawkesbury–Nepean catchment	1: 250 000
Central Mapping Authority of NSW	1982–1984	Topographic maps	1: 100 000 1: 25 000
Geological Survey of NSW	1966	Geological map of Sydney	1: 250 000

Vegetation

Description of map units

A summary of the 15 map units recognised on the St Albans 1: 100 000 vegetation sheet, their structural formations, main canopy species, geology and occurrence are given in Table 3. The map unit numbering system applies to the complete Sydney Region Vegetation Map Series. Missing numbers are those used for plant communities that are not found on the St Albans sheet. The vegetation map is located inside the back cover.

A list of native species recorded in the area and indicating map unit occurrence is given in Appendix 1.

Map unit 6c

Glen Forest

Tall open-forest: *Eucalyptus saligna – Eucalyptus paniculata*

Isolated, small Tertiary volcanic outcrops are scattered throughout the Triassic sandstone. They form deep loamy soils which support Glen Forest, a distinctive flora which varies from outcrop to outcrop. Most outcrops have been altered by agriculture, grazing and logging, such as at Mt Tootie (in the far south-west of the map sheet area) and those scattered along ranges of the Macdonald valley. Two small patches of basalt, however, occur on the western end of the Culoul Range between Six Brothers and Hollow Rock. These have only been partially logged in the past and contain a good representation of Glen Forest flora. They support tall open-forests of Blue Gum *Eucalyptus saligna*, up to 32 m in height, with Ironbark *Eucalyptus paniculata* as a sub-dominant. The understorey includes patches of *Acacia parramattensis* and a dense ground cover of herbs and grasses. Common understorey species include *Indigofera australis*, *Maytenus silvestris*, *Smilax australis*, *Pellaea falcata*, *Geitonoplesium cymosum* and *Doodia aspera* (Haegi & Benson 1981).

Glen Forest is related floristically to Moist Basalt Cap Forest (map unit 6g) of Mt Wilson, Mt Tomah, Mt Bell, Mt Banks, Mt Caley and Mt Hay on the Katoomba vegetation map sheet (Keith & Benson 1988) and to Mt Colong and Mt Shivering of the Burragorang vegetation sheet (Fisher, Ryan & Lembit 1995). They are all tall open-forests supported by deep loams of Tertiary volcanics but altitudinal differences influence floristic composition. Moist Basalt Cap Forest (map unit 6g) occurs at higher altitudes (800–1100 m) and contains Ribbon Gum, *Eucalyptus viminalis*, with *Eucalyptus fastigata* and *Eucalyptus blaxlandii* as sub-dominants; while the lower altitude (200–500 m) Glen Forest contains either of the Blue Gums, *Eucalyptus saligna* (closer to the coast), or *Eucalyptus deanei*.

Map unit 8gr

Gully Rainforest

Rainforest: *Doryphora sassafras – Ceratopetalum apetalum – Acmena smithii – Backhousia myrtifolia – Schizomeria ovata*

Small pockets of rainforest occur in the Colo Gorge and Wheeny Creek area. They occur in deep sheltered gullies below escarpments incised into the Hawkesbury and Narrabeen Group Sandstone and are largely inaccessible. Small areas also occur in the Leets Vale/Maroota area (Douglas 1995).

Species lists for rainforest patches in Wheeny Creek, Floyds Scrub near Wheeny Gap, and Cabbage Tree, Tari and Gospers Creeks have been compiled by Peter Hind and Bob Coveny (pers. comm.). Canopy species include *Livistona australis*, *Ficus rubiginosa*, *Ficus coronata*, *Toona ciliata* and *Ficus superba* var. *henneana*. *Dendrocnide photinophylla*, *Acmena smithii*, *Ceratopetalum apetalum*, *Symplocos thwaitesii*, *Backhousia myrtifolium*, *Cordyline stricta*, *Choricarpia leptopetala* and *Doryphora sassafras*. These rainforest pockets are special for representing the southern limit of several rainforest species. *Dendrocnide photinophylla*, for example, occurs in Floyds Scrub and this is the only occurrence in the Central Coast Botanical Sub-Division.

Map unit 9a
Shale Cap Forest

Patches of Wianamatta Shale exist along some of the higher ridge-tops, particularly in the south of the map sheet area and along the ridge of the Mellong Range. The soils of the shales are higher in nutrients and deeper than those on the adjacent sandstone and, because of the better soils, have had most of the original vegetation cleared for farming.

i) Open-forest: *Eucalyptus paniculata – Eucalyptus crebra – Syncarpia glomulifera*

Patches of Wianamatta Shale occur along the Culoul Range, running west off the Mellong Range into the Colo valley. These support Shale Cap Forest containing *Eucalyptus paniculata*, *Eucalyptus eugenioides*, *Syncarpia glomulifera*, *Eucalyptus notabilis* and *Eucalyptus punctata*. Similar vegetation would have occurred at Colo Heights and other, now cleared, shale areas along the Putty Road (*Eucalyptus crebra* also occurs on shale along the Putty Road) and along the Old Northern Road south of Wisemans Ferry.

The Culoul Shale Cap Forest is mostly open-forest structure though logging has temporarily opened up parts of the canopy. A variable understorey of tree saplings and shrubs, particularly *Acacia parramattensis, Acacia paradoxa* and *Acacia longifolia*, are present while the ground layer is dense to mid-dense with herbs, grasses and twiners and some small shrubs. Common species include *Dianella revoluta, Bursaria spinosa, Goodenia ovata,*

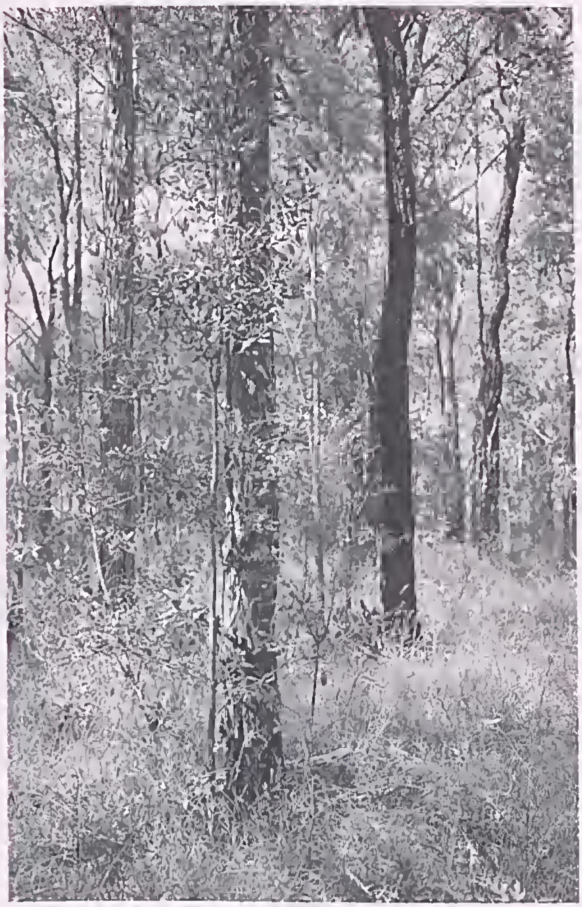

Fig. 5. Lower-growing Turpentine–Ironbark Forest with grassy understorey of *Themeda australis* is characteristic of drier shale situations, such as shale-capped ridgetops near Colo Heights (subunit of Map Unit 9a).

Table 3. Map unit, common name, structure, main canopy species, geology and occurrence of plant communities in the area covered by the St Albans 1: 100 000 map sheet.

Map unit	Structure	Main canopy species	Geology	Occurrence
6c	**Glen Forest**			
	Tall open-forest	*Eucalyptus saligna* *Eucalyptus paniculata*	Tertiary volcanics	Isolated outcrops e.g. Culoul Range
8gr	**Gully Rainforest**			
	Closed-forest	*Doryphora sassafras* *Ceratopetalum apetalum* *Acmena smithii* *Backhousia myrtifolia* *Schizomeria ovata*	Enriched alluvium	Deep gullies, Wheeny Creek, Colo Gorge
9a	**Shale Cap Forest**			
	Open-forest	*Eucalyptus paniculata* *Eucalyptus crebra* *Syncarpia glomulifera*	Wianamatta Shale	Cappings on ridgetops, lower rainfall e.g. Putty Road
	Tall open-forest	*Eucalyptus deanei* *Eucalyptus cypellocarpa* *Syncarpia glomulifera*		Higher rainfall, Mountain Lagoon
9h	**Hawkesbury–Narrabeen Sheltered Forest**			
	Tall open-forest/ Open-forest	*Eucalyptus deanei* *Eucalyptus saligna* *Syncarpia glomulifera* *Angophora floribunda*	Hawkesbury Sandstone, Narrabeen Group	Lower slopes, sheltered gullies, Colo and Hawkesbury Rivers
9xc	**Colo Gorge Forest**			
	Open-forest	*Eucalyptus deanei* *Eucalyptus saligna* *Eucalyptus elata*	Floodplain alluvium	River-flats, below Upper Colo
	Woodland/ Open-forest	*Eucalyptus agglomerata* *Angophora floribunda* *Syncarpia glomulifera* *Eucalyptus deanei*	Narrabeen Group, alluvium	Upper Colo River, Wollemi Creek
	Closed-forest	*Ceratopetalum apetalum* *Tristaniopsis laurina* *Acmena smithii*		
	Open-scrub	*Casuarina cunninghamiana* *Tristaniopsis laurina* *Leptospermum polygalifolium*		
10af	**Rough-barked Apple Woodland**			
	Woodland	*Angophora floribunda* *Eucalyptus tereticornis* *Eucalyptus amplifolia*	Quaternary alluvium	Valley flats and creek lines
10ag	**Sydney Sandstone Gully Forest**			
	Open-forest	*Angophora costata* *Eucalyptus piperita* *Eucalyptus agglomerata* *Syncarpia glomulifera*	Hawkesbury Sandstone, Narrabeen Group	Sheltered slopes and gullies

Map unit	Structure	Main canopy species	Geology	Occurrence
10ar	**Sydney Sandstone Ridgetop Woodland**			
	Low open-woodland/ Woodland	*Corymbia eximia* *Angophora bakeri* *Corymbia gummifera* *Angophora costata* *Eucalyptus punctata*	Triassic Hawkesbury and Narrabeen Group sandstone	Exposed slopes and ridges
	Heath/Scrub/ Woodland	*Calytrix tetragona* *Darwinia fascicularis* subsp. *oligantha* *Eucalyptus haemastoma* *Eucalyptus squamosa* *Corymbia gummifera*	Tertiary sand, gravel	Maroota Sandmass Complex
	Open-forest	*Eucalyptus pilularis* *Angophora costata*	Mittagong Formation	Wheelbarrow Ridge
10me	**Mellong Woodlands**			
	Woodland	*Eucalyptus sclerophylla* *Angophora bakeri*	Quaternary alluvium	Mellong Plateau, well-drained sites
	Woodland	*Eucalyptus parramattensis*		Poorly-drained sites
10ni	**Narrabeen–Hawkesbury Ironbark Woodland**			
	Woodland	*Corymbia eximia* *Eucalyptus fibrosa* *Eucalyptus crebra* *Eucalyptus beyeriana*	Narrabeen Group sandstone, shale lenses	Slopes and ridges with localised clay soils
21j	**Dwarf Apple Scrub**			
	Open-scrub	*Angophora hispida*	Hawkesbury Sandstone	Ridges and exposed slopes north of Wheelbarrow Ridge
27a	**Estuarine Complex**			
	Low Open-forest	*Casuarina glauca*	Quaternary alluvium	Floodplain, Webbs Creek,
	Closed-scrub	*Melaleuca ericifolia*		Hawkesbury River below Wisemans Ferry
27me	**Mellong Swamps**			
	Sedgeland	*Lepyrodia scariosa* *Schoenus brevifolius*	Quaternary alluvium	Mellong Plateau, waterlogged soils
28a	**Freshwater Reed Swamps**			
	Open-sedgeland	*Eleocharis sphacelata* *Juncus usitatus* *Persicaria hydropiper*	Quaternary alluvium	Lower Colo, Macdonald and Hawkesbury Rivers
	Tall Shrubland	*Melaleuca linariifolia*		Creekflats
	Sedgeland	*Lepidosperma longitudinale* *Melaleuca linariifolia*		Mountain Lagoon
C	**Cleared**	Cleared areas are generally those sites with the better agricultural soils such as the riverflats or shale and basalt cappings		

Hardenbergia violacea, Indigofera australis, Kennedia rubicunda, Goodenia ovata and *Smilax australis*. Grasses include *Echinopogon caespitosum* and *Panicum simile* (Haegi & Benson 1981)

ii) Tall open-forest: *Eucalyptus deanei – Eucalyptus cypellocarpa – Syncarpia glomulifera*

Shale Cap Forest also occurs in the southwest corner of the map sheet. On Wianamatta Shale at Mountain Lagoon, in a shallow valley and with annual rainfall of more than 1200 mm (higher than elsewhere on the map sheet), remnant trees of *Eucalyptus deanei*, 35 to 40 m high indicate the former occurrence of tall open-forest. The tall forest has almost all been cleared for farming but in some remnant areas are trees of *Eucalyptus deanei, Eucalyptus cypellocarpa, Syncarpia glomulifera, Eucalyptus punctata* and *Eucalyptus globoidea*. Groundcover shrubs include *Pultenaea flexilis, Goodenia ovata, Smilax australis, Lomandra longifolia, Blechnum cartilagineum, Microlaena stipoides, Echinopogon ovatus, Polyscias sambucifolius* and *Bracteantha bracteata*.

Similar vegetation and extends south on ridges along the Bells Line of Road from Kurragong Heights to Bilpin, and near Springwood (on the Penrith and Katoomba 1: 100 000 vegetation sheets (Benson 1992, Keith & Benson 1988)). Shale Cap Forest is closely related to Ironbark Forest (map unit 9c in Benson 1992) that occurs south of Springwood where rainfall is lower. Shale Cap Forest and Ironbark Forest are both part of the broadly defined Turpentine–Ironbark Forest of Benson & Howell (1990).

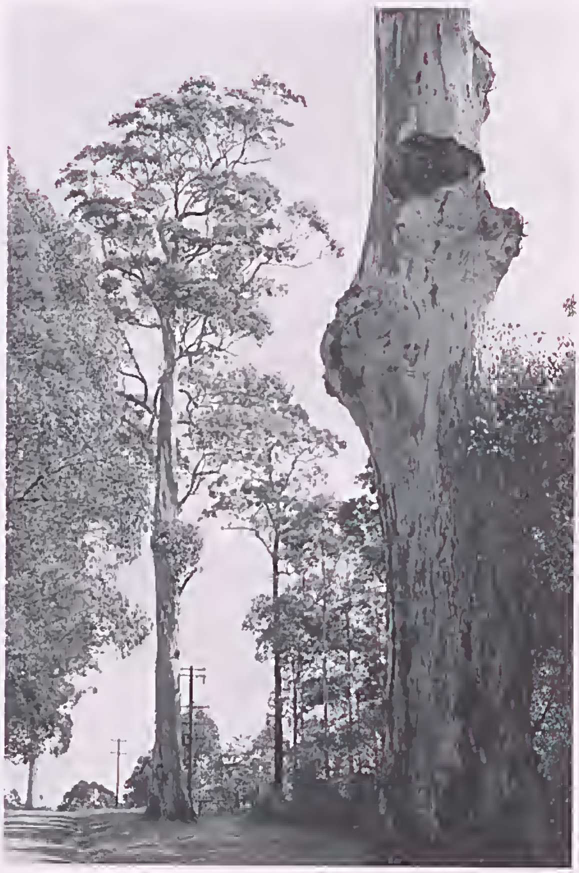

Fig. 6. Large remnant trees of *Eucalyptus deanei* on shale soil in the valley at Mountain Lagoon (subunit of Map Unit 9a), indicate that the forest attained heights of at least 40 m growing in these sheltered, higher-rainfall conditions.

Map unit 9h
Hawkesbury–Narrabeen Sheltered Forest

Open-forest to Tall open-forest: *Eucalyptus deanei – Eucalyptus saligna – Syncarpia glomulifera – Angophora floribunda*

Hawkesbury–Narrabeen Sheltered Forest is confined to the valley floors and sheltered gullies on high fertility alluvial soils of Hawkesbury and Narrabeen Group sandstones. It occurs along the lower reaches of the Colo and Hawkesbury Rivers where its canopy may cover up to 60% and its low tree canopy may cover up to 80%. Tall canopy tree species include *Eucalyptus deanei* and *Eucalyptus saligna*. These two Blue Gums rarely occur together although their distributions meet in Wheeny Creek in this Sheltered Forest Community. *Syncarpia glomulifera* and *Angophora floribunda* also occur with the Blue Gums, but a little further upslope where the ground is better drained. *Allocasuarina torulosa* may also occur on the lower slopes which flank the gully forest as well as *Eucalyptus piperita, Angophora costata* and *Eucalyptus paniculata*. *Casuarina cunninghamiana* occurs as a riparian species along the Colo and Macdonald Rivers. *Eucalyptus elata* also occurs as a riverside species in the lower Colo River below Upper Colo, with *Eucalyptus saligna*. *Eucalyptus michaeliana* is a rare and significant species and occurs along the Macdonald River valley in drier gullies (Bell et al. 1993). A low tree layer of *Backhousia myrtifolia* is characteristic of the Sheltered Gully Forest and may form a main, low tree canopy at many sites.

Associated species in the understorey include *Rapanea variabilis, Dodonea triquetra, Acacia*

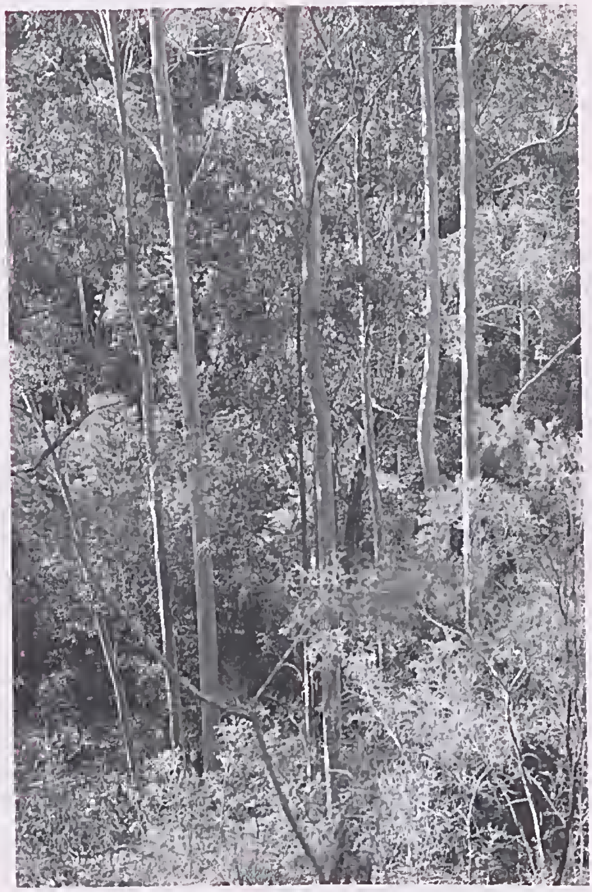

Fig. 7. Tall open-forest of *Eucalyptus saligna* with understorey of shrubs and small trees along Wheeny Creek (Map Unit 9h).

parvipinnula, *Hibiscus heterophylla*, *Ficus rubiginosa*, *Notelaea longifolia*, *Maytenus sylvestris*, *Persoonia linearis* and *Platysace lanceolatus*. Climbers such as *Cissus hypoglauca*, *Cissus antarctica* and *Smilax australis*, and the fern, *Calochlaena dubia*, are common. The rare species *Callistemon shiressii*, *Platysace clelandii* and *Eucalyptus michaeliana* have been recorded in Sheltered Gully Forest (Bell et al. 1993).

Hawkesbury–Nepean Sheltered Forest was found to be extensive in the Macdonald valley by Bell et al. (1993) and we found it beyond the western boundary of Yengo National Park in gullies draining to the Colo River along the Mellong Range, for example. Benson (1986) reported that Hawkesbury–Nepean Sheltered Forest extended further east to Mogo, Mangrove and Mooney Mooney Creeks (map unit 9h on the Gosford 1: 100 000 sheet).

Map unit 9xc
Colo Gorge Forest

i) Open-forest: *Eucalyptus deanei – Eucalyptus saligna – Eucalyptus elata*

The Colo is a perennially flowing river, flanked by alluvial flats along its lower reaches. These have remnants of River-flat Forest with trees of *Eucalyptus deanei*, *Eucalyptus saligna* and *Eucalyptus elata* together with *Casuarina cunninghamiana* and *Angophora floribunda*. In sheltered sites patches of mesic understorey occur with *Acmena smithii*, *Trema aspera*, *Ficus coronata*, *Duboisia myoporoides* and *Tristaniopsis laurina*. Vines such as *Eustrephus latifolius*, *Geitonoplesium cymosum* and *Pandorea pandorana* occur and ferns such as *Doodia aspera* and *Adiantum aethiopicum*. In more open sites are shrubs of

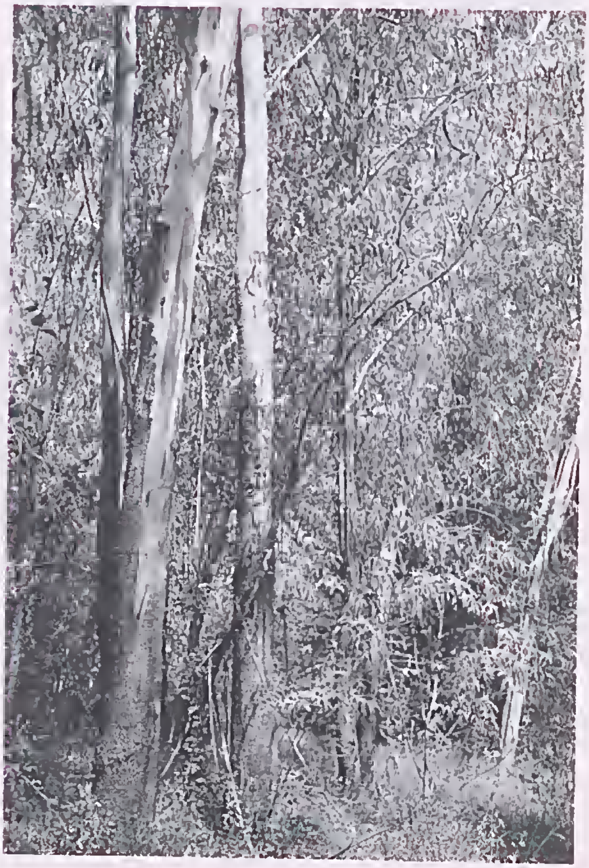

Fig. 8. River Peppermints, *Eucalyptus elata*, in River-flat Forest beside the Colo River near Upper Colo.

Acacia filicifolia and *Leptospermum polygalifolium* occur with *Pteridium esculentum* (Benson 1974). Similar vegetation occurs along the lower Hawkesbury though the main eucalypt there appears to have been *Eucalyptus tereticornis* (see Benson & Howell 1993, Howell, McDougall & Benson 1995).

Above Upper Colo, however, the River is deeply entrenched, often about 250 m below the general level of the surrounding plateau. Alluvial flats are very limited and the valley is very narrow, often only about 100 m wide, and in many places flanked by towering cliffs with numerous rock ledges where small trees and shrubs are able to gain a foothold. A range of vegetation occurs in the gorge (Haegi & Benson 1981).

ii) Woodland/Open-forest: *Eucalyptus agglomerata – Eucalyptus punctata – Syncarpia glomulifera – Eucalyptus deanei*

The steep-sided talus slopes of the Colo escarpments, with a mixture of shaley and sandstone soils, support woodland and open-forest. Trees of *Eucalyptus agglomerata* and *Eucalyptus punctata* occur on upper slopes while taller forest with *Angophora floribunda, Syncarpia glomulifera, Eucalyptus deanei* and occasionally *Eucalyptus saligna* occurs on the lower slopes, particularly on sheltered aspects and extending into side gullies. *Backhousia myrtifolia* is a very common shrub species, occurring with *Rapanea variabilis, Glochidion ferdinandii, Dodonaea triquetra, Prostanthera prunelloides, Ceratopetalum apetalum* and *Acacia parvipinnula*. Ground plants include *Lomandra longifolia, Lepidosperma laterale, Gahnia aspera* and *Adiantum aethiopicum*.

iii) Closed-forest: *Ceratopetalum apetalum – Tristaniopsis laurina – Acmena smithii*

Side gullies may also have closed-forest with *Ceratopetalum apetalum, Tristaniopsis laurina, Acmena smithii, Acacia elata, Backhousia myrtifolia* and occasional *Doryphora sassafras*.

iv) Open-scrub: *Casuarina cunninghamiana – Tristaniopsis laurina – Leptospermum polygalifolium*

The floor of the Colo Gorge has large expanses of bare sand where the river forms large shallow pools, rocky sections with rapids, and deep pools

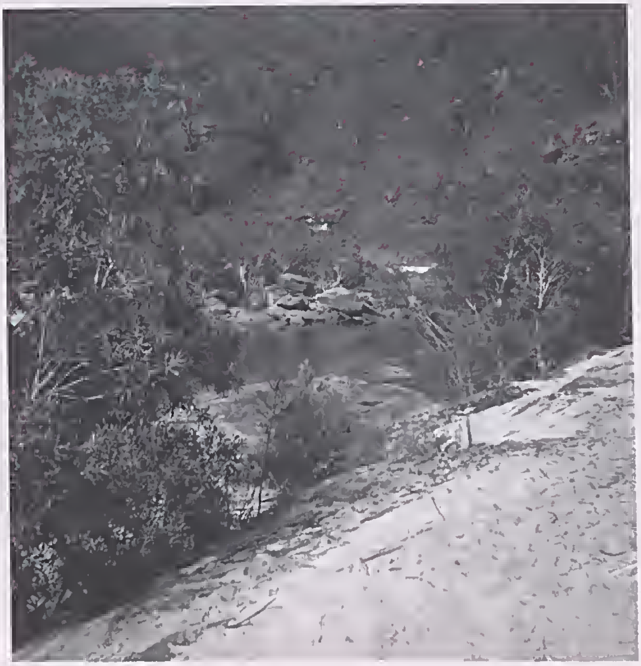

Fig. 9. The floor of the Colo Gorge near the junction with Boorai Creek showing patches of *Tristaniopsis laurina* and *Leptospermum polygalifolium* scrub.

dammed up by massive boulders which have fallen from cliff faces into the gorge. In the rocky areas which are periodically ravaged by the fiercely flowing waters of the flooded river, patches of open-scrub with *Casuarina cunninghamiana*, *Tristaniopsis laurina*, *Leptospermum polygalifolium*, *Leptospermum spectabile* (endemic to the Colo Gorge), *Austromyrtus tenuifolia* and *Lomandra longifolia*. On open sites of alluvial sand and loam, herbaceous and soft-wooded colonising species, both native and naturalised are frequently prolific. Amongst these are *Opercularia aspera*, *Prostanthera ovalifolia*, *Trema aspera* and the exotics *Conyza albida*, *Hypochaeris radicata*, *Datura stramonium* and *Aster subulatus*.

Map unit 10af
Rough-barked Apple Woodland

Woodland: *Angophora floribunda – Eucalyptus tereticornis – Eucalyptus amplifolia*

Rough-barked Apple Woodland occurs on perched silty sediments on the alluvial flats of valleys and along drainage lines. It is likely that it was more widespread on broad alluvial valleys along major water courses although these habitats have been mostly cleared for agriculture, owing to the suitability of their soils for agriculture. Bell et al. (1993) recorded Rough-barked Apple Woodland in the tributaries of the Macdonald River and at the foot of Mt Yengo and Mt Wareng further north.

Rough-barked Apple Woodland is composed mostly of *Angophora floribunda* but also contains Red Gums, *Eucalyptus tereticornis* and *Eucalyptus amplifolia*. Canopy cover is usually 45–60%, and trees are mostly 15–25 m tall. Rough-barked Apple Woodland sometimes grades into an open-forest with *Eucalyptus saligna* and *Eucalyptus piperita* occurring as occasional emergents. The shrub layer is usually quite sparse having a cover of up to 30%. Common understorey species include *Acacia filicifolia*, *Acacia parramattensis* and *Persoonia linearis*. The ground layer is very dense, often with a cover of 90–100%. Common herb and grass species include *Pratia purpurascens*, *Cheilanthes sieberi*, *Dichondra repens*, *Veronica plebeia*, *Panicum simile*, *Echinopogon caespitosus* and *Imperata cylindrica*.

Map unit 10ag
Sydney Sandstone Gully Forest

Open-forest: *Angophora costata – Eucalyptus piperita – Eucalyptus agglomerata – Syncarpia glomulifera*

Sydney Sandstone Gully Forest, together with Sydney Sandstone Ridgetop Woodland (map unit 10ar), are widely distributed on the Triassic sandstone plateau of the Sydney Basin. Sydney Sandstone Gully Forest occurs on sheltered slopes and in gullies of the Hawkesbury and Narrabeen Group sandstone on moist, well-drained, shallow, sandy-loams. Tree species include *Angophora costata, Eucalyptus piperita, Syncarpia glomulifera* and occasionally *Eucalyptus punctata* and *Corymbia gummifera*. *Eucalyptus agglomerata* is part of the canopy in the most sheltered positions where canopy cover reaches 70%, though generally on the slopes, canopy cover is 30–50%. *Eucalyptus agglomerata* is relatively abundant in the Dyarrabin Nature Reserve proposal e.g. Maroota – Lower Portland – Leets Vale (Douglas 1995).

Depending on the degree of exposure, the understorey may vary greatly in terms of cover and abundance. It may be composed of a small tree layer of *Allocasuarina torulosa* and *Backhousia myrtifolia*, ranging from 5–20% but more commonly is a shrub layer which may vary from 10–70% cover. Common shrubs include *Persoonia linearis, Elaeocarpus reticularis, Cerratopetalum apetalum, Platysace lanceolata, Platysace linearfolia, Lomatia silaifolia, Acacia terminalis, Pultenaea flexilis* and *Gompholobium latifolium*. *Pteridium esculentum* and *Calochlaena dubia* are also common in the understorey. Vines such as *Smilax glycophylla* and *Billardiera scandens* occur frequently. The rare and endangered species *Zieria involucrata* and *Platysace clelandii* have been recorded in this community (Bell et al. 1993).

Sydney Sandstone Gully Forest extends north and south of the St Albans map sheet. It is equivalent to Bell et al. (1993)'s Sheltered Dry Hawkesbury Forest in Yengo National Park and north to the Hunter Range. Sydney Sandstone Gully Forest also occurs on other vegetation sheets covering the Hawkesbury–Nepean catchment (Benson 1986, 1992; Keith & Benson 1988; Benson & Keith 1990; Benson & Howell 1994a).

Map unit 10ar
Sydney Sandstone Ridgetop Woodland

i) Woodland: *Corymbia eximia – Angophora bakeri – Corymbia gummifera – Angophora costata – Eucalyptus sparsifolia – Eucalyptus punctata*

Sydney Sandstone Ridgetop Woodland is widely distributed on Hawkesbury and Narrabeen Group sandstones, on ridges and exposed northern and western slopes. Soils are generally shallow, well-drained skeletal sands, sandy loams or sandy clays. Ridgetops support woodlands to low open-woodlands of *Corymbia* [formerly Eucalyptus] *eximia* and *Angophora bakeri*. Slopes and ridges support *Corymbia gummifera, Eucalyptus sparsifolia, Eucalyptus punctata, Angophora costata* and occasional *Eucalyptus notabilis, Eucalyptus fibrosa* and *Eucalyptus beyeriana*.

On sandstone with a higher shale content, especially the Narrabeen Group sandstones, or on shale lenses of Hawkesbury Sandstone, more clayey soils give rise to Ironbarks and Turpentine, *Syncarpia glomulifera* which become common and sometimes dominant. Grey Ironbark, *Eucalyptus paniculata,* occurs on slopes and in sheltered positions while Narrow-leaved Ironbark, *Eucalyptus crebra* occurs on exposed slopes and ridges. In poorly-drained areas, woodlands of Scribbly Gum, *Eucalyptus sclerophylla* occur.

Common shrubs in Hawkesbury Sandstone Woodland include *Leptospermum trinervium, Monotoca scoparia, Phyllanthus hirtellus, Hovea linearis, Lambertia formosa, Persoonia linearis, Acacia suaveolens, Persoonia laevis* and *Lambertia formosa.* In the understorey of exposed Narrabeen sandstone communities, shrubs such as *Pultenaea microphylla, Oxylobium ilicifolium* and *Astrotricha obovata* are common. Rare and endangered species recorded include *Tetratheca glandulosa, Olearia cordata, Lissanthe sapida* and *Platysace clelandii* (Bell et al. 1993).

Sydney Sandstone Ridgetop Woodland largely includes Bell et al. 's (1993) Yengo National Park units, Exposed Hawkesbury Woodland, Exposed Narrabeen Woodland and Narrabeen–Hawkesbury Ironbark Forest. These communities extend beyond

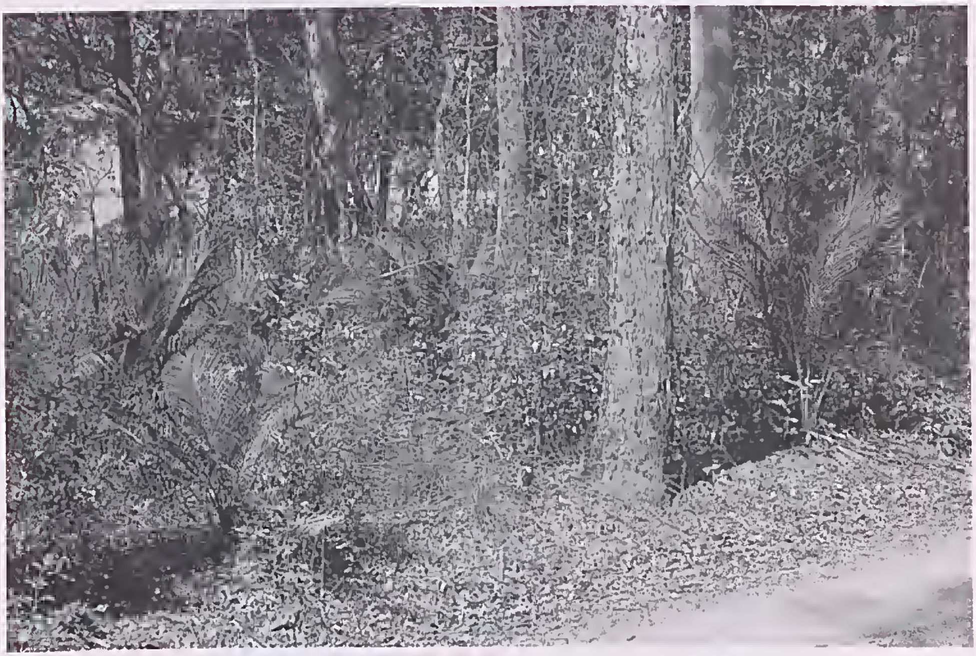

Fig. 10. Burrawang, *Macrozamia communis*, is a localised understorey component in woodland with *Corymbia gummifera* and *Angophora costata* on sandstone ridgetops near Colo Heights (Map Unit 10ar).

the St Albans map sheet. Sydney Sandstone Ridgetop Woodland also occurs on other vegetation sheets covering the Hawkesbury–Nepean catchment (Benson 1986, 1992; Keith & Benson 1988; Benson & Keith 1990; Benson & Howell 1994a).

ii) Maroota Sandmass Complex

On the Maroota Sandmass is an extremely complex and changeable vegetation assemblage that merges with the Sydney Sandstone Ridgetop Woodland (Douglas 1996). It is restricted to the south-east corner of the map sheet between Maroota and Metheringhams Hill, south of Wisemans Ferry. Vegetation ranges from heath with *Calytrix tetragona*, *Darwinia fascicularis* subsp. *oligantha*, *Phebalium squamulosum* and *Philotheca salsolifolia*, wet heath with *Banksia oblongifolia*, dry scrub with *Angophora hispida*, to woodland with *Eucalyptus haemastoma*, *Eucalyptus squamosa*, *Corymbia gummifera* and *Angophora bakeri*, and forest with *Corymbia gummifera*, *Eucalyptus globoidea*, *Eucalyptus punctata* and *Angophora costata* (Douglas 1996). Remaining vegetation is mostly restricted to the margins of the sandmass as the bulk of the sandmass has been cleared.

iii) Open-forest: *Eucalyptus pilularis – Angophora costata*

In areas of higher rainfall, in the south-east of the map sheet area, particularly along Wheelbarrow Ridge and in Parr State Recreation Area, open-forest of Blackbutt, *Eucalyptus pilularis*, occurs on soils from the fine-grained sandstone of the Mittagong Formation. Soils here have sandy topsoils overlying yellow clayey subsoils with stratified ironstone plates. *Eucalyptus pilularis* is characteristic of moister coastal forests, particularly in the Wyong area further east (map unit 9g, Benson 1986). Its occurrence along Wheelbarrow Ridge appears to be its western geographical limit in this area. Other tree species occurring with *Eucalyptus pilularis* include *Angophora costata*, *Syncarpia glomulifera*, *Allocasuarina torulosa*, *Eucalyptus punctata* and *Corymbia* [formerly *Eucalyptus*] *gummifera*. Understorey species include *Persoonia linearis*, *Bossiaea obcordata*, *Lomatia silaifolia*, *Pultenaea scabra*, *Stypandra glauca*, *Dianella revoluta*, *Persoonia laevis*, *Entolasia stricta*, *Lomandra obliqua*, *Pteridium esculentum*, *Billardiera scandens* and *Themeda australis*.

Map unit 10me
Mellong Woodland

i) Woodland: *Eucalyptus sclerophylla – Angophora bakeri*

The Mellong Plateau has extensive alluvial deposits of deep leached sands and the vegetation is determined by the low nutrient levels of the sands and the conditions and durat. On the higher parts of the system, the soils are more aerated and better drained, and open-woodland with trees of *Angophora bakeri* and *Eucalyptus sclerophylla* occurs. The understorey is shrubby and may include *Leptospermum trinervium*, *Isopogon anemonifolius*, *Bossiaea heterophylla*, *Hakea dactyloides*, *Banksia spinulosa*, *Cryptandra spinescens*, *Monotoca scoparia*, *Pteridium esculentum*, *Platysace ericoides*, *Haemodorum planifolium*, *Gompholobium latifolium* and *Lindsaea linearis*.

ii) Woodland: *Eucalyptus parramattensis*

Where drainage is poorer and sites are periodically wet woodland with *Eucalyptus parramattensis* with shrubs and sedges predominates. Shrubs include *Banksia spinulosa*, *Melaleuca thymifolia*, *Baeckea diosmifolia* and *Leptospermum juniperinum*, and groundlayer species include *Lepyrodia scariosa* sens lat, *Themeda australis*, *Ptilothrix deustum*, *Cyathochaeta diandra*, *Aristida calycina*, *Leptocarpus tenax*, *Lindsaea linearis* and *Gonocarpus micranthus*. This vegetation grades into Mellong Swamp vegetation, Map unit 27me, in poorly-drained sites.

In her survey on the Mellong Plateau, Howard (1981) described Mellong Woodland as the *Eucalyptus parramattensis* / *Banksia spinulosa* / Restionaceae Woodland and found it represented in all swamp systems on the Plateau. Mellong Woodland includes Woodland on Perched Sands and Swamp Woodland on Perched Sands described for Yengo National Park (Bell et al. 1993).

Map unit 10ni
Narrabeen–Hawkesbury Ironbark Woodland

Woodland: *Corymbia eximia – Eucalyptus fibrosa – Eucalyptus crebra – Eucalyptus beyeriana*

Narrabeen–Hawkesbury Ironbark Woodland is found mainly on the Narrabeen Series geology or on shale lenses of the Hawkesbury Sandstone. Soils are well-drained, skeletal or sometimes shallow, sandy loam or sandy clay. This woodland is most common on exposed slopes and ridges but may also occur on lower slopes and gullies. Narrabeen–Hawkesbury Ironbark Woodland is difficult to distinguish on air photos from Sydney Sandstone Exposed Woodland (map unit 10ar), but appears to occur most extensively in the upper Macdonald valley and extends north onto the Howes Valley 1: 100 000 map sheet where Narrabeen Group sandstone commonly outcrops (Benson & Howell 1994b). It is equivalent to Narrabeen–Hawkesbury Ironbark Forest (map unit 4b) in Bell et al. (1993).

Narrabeen–Hawkesbury Ironbark Woodland is dominated by the typical Sydney sandstone species *Corymbia eximia* and by shaley sandstone Ironbarks *Eucalyptus fibrosa*, *Eucalyptus* crebra or *Eucalyptus beyeriana*. *Acacia parvipinnula* is common in the shrub layer along with other taller shrubs including *Persoonia linearis*, *Oxylobium ilicifolium* and *Pultenaea scabra*. Ground cover varies from sparse and grassy (*Themeda australis)* to dense and ferny *(Adiantum* sp.). Frequent herbs include *Pomax umbellata*, *Entolasia stricta*, *Hardenbergia violaceae* and *Dianella revoluta*.

Map unit 21j
Dwarf Apple Scrub

Open-scrub: *Angophora hispida*

On exposed Hawkesbury Sandstone outcrops with shallow skeletal soils the Exposed Hawkesbury Sandstone community (map unit 10ar) is replaced by open-scrub dominated by *Angophora hispida*. This

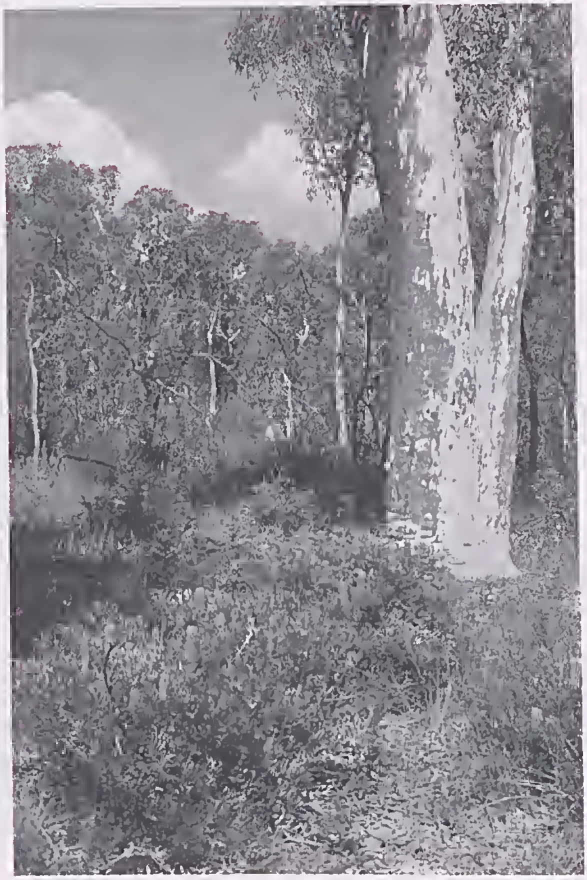

Fig. 11. On the deep sands of the Mellong Plateau, large trees of Scribbly Gum, *Eucalyptus sclerophylla*, are features of the Mellong Woodland (Map Unit 10me).

occurs particularly along ridges, north and north-east of Wheelbarrow Ridge Road.

Tree cover is generally 5–10% with only infrequent emergents, such as *Eucalyptus sclerophylla, Angophora costata, Eucalyptus sparsifolia* and the Ironbarks, *Eucalyptus crebra, Eucalyptus fibrosa* and *Eucalyptus beyeriana*. Shrubs include *Hakea dactyloides, Leptospermum trinervium, Bosseaea heterophylla, Banksia spinulosa, Banksia oblongifolia, Leucopogon microphyllus, Lambertia formosa, Petrophile pulchella* and *Isopogon anemonifolius*. This taller shrub layer has no more than 5–15% cover. Herbaceous species include *Ptilothrix deusta, Lomandra glauca, Patersonia sericea, Dampiera stricta* and *Lomandra obliqua*.

Dwarf Apple Scrub is equivalent Dwarf Apple Low open-woodland in Bell et al. (1993) for Yengo National Park. Benson (1992) describes Dwarf Apple Scrub as a sub-unit of Sydney Sandstone Ridgetop Woodland.

Map unit 27a
Estuarine Complex

i) Low Open-forest: *Casuarina glauca*

Associated with the floodplain of the Hawkesbury River around and downstream of Wisemans Ferry, and in lower Webbs Creek are areas of estuarine and brackish water vegetation. *Casuarina glauca* occurs on the riverflats and along creek banks with *Phragmites australis* as the main understorey species. River Mangrove, *Aegiceras corniculatum* reaches its upstream limit near Wisemans Ferry, forming a narrow line along the foreshores, with *Phragmites australis*, and sometimes with *Melaleuca styphelioides* higher on the bank.

ii) Closed Scrub: *Melaleuca ericifolia*

In some areas *Melaleuca ericifolia* forms pure dense thicket-like stands up to 6m high. These are often adjacent to pure stands of *Casuarina glauca*, possibly indicating slightly different drainage or salinity conditions. *Melaleuca ericifolia* suckers readily after burning. Small patches of sedgeland with *Eleocharis equisitina, Isolepis inundata* and *Paspalum distichum* also occur, probably indicating less brackish conditions than the *Melaleuca* or *Casuarina*. The uncommon *Cladium procerum* occurs along Webbs Creek (Stricker & Wall 1995). Swamp Mahogany Forest with *Eucalyptus robusta* may also occur in sheltered sites at the freshwater end of Estuarine Complex vegetation but has been almost all cleared and is now rare.

Map unit 27me
Mellong Swamps

Sedgeland: *Lepyrodia scariosa – Schoenus brevifolius*

The Mellong Swamps are dominated by sedges and occasionally shrubs. They occur scattered across the swampy series of shallow valleys that characterises the Mellong Plateau, on sandy alluvium with little accumulation of peat. Podsols are widespread in silty and clayey sand on flats and low slopes but are not found on all sites. Most swamps dry out at the surface after less than three months of drought.

Lepyrodia scariosa and *Schoenus brevifolius* occur with herbs such as *Selaginella uliginosa, Dichondra repens, Gonocarpus micranthus, Goodenia paniculata* and *Drosera peltata*. On more constantly moist soils, *Carex* tussock sedgelands occur, while on moister, but not sodden, soils open-scrubs of *Leptospermum juniperinum* occur. On constantly moist but drained soils, low open forest of *Melaleuca linariifolia* occurs while along drainage lines *Callistemon citrinus* and *Melaleuca linariifolia* are common.

The Mellong Swamps are included in Swamp Woodland on Perched Sands in Bell et al. (1993).

Map unit 28a
Freshwater Reed Swamps

i) Open-sedgeland: *Eleocharis sphacelata – Juncus usitatus – Persicaria hydropiper*

Freshwater swamps are an important component of the floodplains of the major rivers, the Macdonald and its tributaries Wrights and Webbs Creek, the Colo, below Upper Colo and the Hawkesbury. Swamps occur on Quaternary alluvium where small watercourses and drainage lines join the main river channel, and are generally separated from the main river channel by a levee bank. They are traditionally known as 'backswamps'. The original extent of wetlands in the Colo, Macdonald and Hawkesbury was mapped by Benson (1974), with more details for species along the Hawkesbury in Benson & Howell (1993). Stricker & Wall (1995) described and assessed the wetlands of the map sheet area in their study of the wetlands of the Hawkesbury–Nepean Catchment.

Characteristic sedge and large herbaceous species of the Freshwater Reed Swamps of the floodplains are *Eleocharis sphacelata, Persicaria hydropiper, Persicaria strigosa, Juncus usitatus, Paspalum distichum* and *Triglochin procera*. Other species include *Ludwigia peploides* subsp. *montevidensis, Schoenoplectus validus, Schoenoplectus mucronatus, Philydrum lanuginosum, Potamogeton tricarinatus, Persicaria decipiens, Cyperus polystachyos, Ranunculus inundatus, Ottelia ovalifolia, Carex appressa, Juncus prismatocarpus* and *Cyperus exultatus*. On the higher ground, *Casuarina glauca* and *Melaleuca ericifolia* may occur.

Several of the Colo River lagoons including Gees, Gospers and Greens Swamp support the relatively uncommon 3m high sedge, *Lepironia articulata*, while some have the rare aquatic *Brasenia schreberi*. *Panicum bisulcatum*, Black Seeded Panic, a native grass not well-documented for the Central Coast Botanical Sub-division occurs in Wrights Creek and at The Grove in Webbs Creek.

While most of the floodplain forest has been cleared, many of the swamps provide a focus for remnant vegetation as well as native wildlife, and they are protected by legislation. The Colo River includes the extensive Wheeny Creek Swamp and Turnbulls Swamp and other wetlands with a high degree of physical integrity with complete vegetation structure and zonation not commonly seen in floodplain wetlands in the Sydney Region (Stricker & Wall 1995). Important wetlands on the lower Hawkesbury include Blundells Swamp at Lower Portland and Jacksons Swamp at Leets Vale (Douglas 1995). St Albans Common is the largest wetland in the Macdonald Valley and despite grazing is an important area of native sedgelands. Exotic species such as **Axinopus affinus, *Conyza* spp., **Paspalum dilatatum* and **Cirsium vulgare* establish in response to grazing and disturbance. In general the wetlands of the Macdonald need sympathetic management to ensure that the primarily agricultural land uses in these valleys are compatible with the viability of the wetlands (Stricker & Wall 1995).

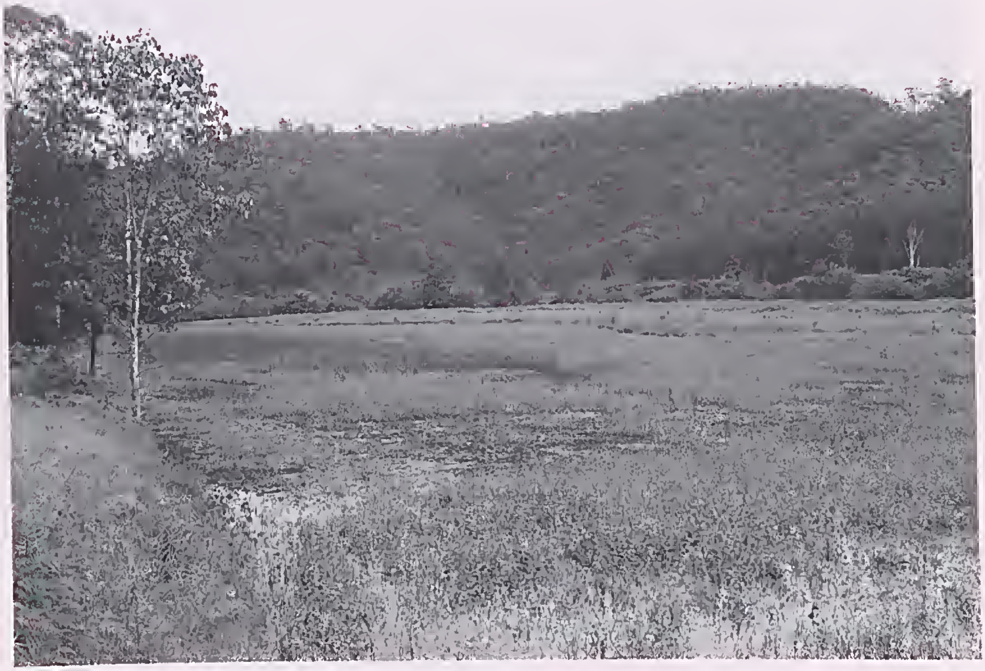

Fig. 12. Backswamp wetlands such as here at St Albans Common are important components of the creek and river floodplains, and vary in habitat conditions and floristic composition (Map Unit 28a).

ii) Low Open-forest: *Melaleuca linariifolia*

Melaleuca linariifolia low open-forest frequently forms a marginal zone around freshwater wetlands and may be particularly extensive on the upstream side of creeks feeding into backswamps. *Melaleuca linariifolia* also occurs widely throughout the map sheet area on poorly-drained creek-flats. Creeks running west and south-west off the Mellong Range into the Colo River, such as Yard Creek and Little Angorawa Creek, support ribbon-like communities of Swamp-forest dominated by *Melaleuca linariifolia*, 14–16 m tall and generally has a canopy cover of about 60%. There may also be a thinner tall shrub layer about 4–8 m tall with a cover of 25–20% generally with *Acacia parramattensis* and *Leptospermum continentale*. Sydney Blue Gum, *Eucalyptus saligna* may occur occasionally as an emergent. Common ground species include *Carex appressa* and *Hypolepis muelleri*. *Melaleuca* Swamp-forest is equivalent to *Melaleuca* Swamp Forest of Bell et al. (1993).

iii) Sedgeland: *Lepidosperma longitudinale – Melaleuca linariifolia*

On the headwaters of Gospers Creek, about 10 km east of Bilpin is an interesting wetland known as Mountain Lagoon. It is in a small basin-shaped valley at 540 m elevation, on a remnant of Wianamatta Shale that has now been mostly cleared. Its topography is apparently related to the formation of the Lapstone Monocline and Kurrajong Fault (Stricker & Wall 1995).

The Lagoon has open water and sedgeland areas with *Lepidosperma longitudinale*, *Baumea rubiginosa*, *Eleocharis* sp., *Nymphoides geminata*, *Ranunculus repens*, *Juncus usitatus*, *Juncus planifolius*, *Selaginella uliginosa* and *Sphagnum* sp. Small trees of *Melaleuca linariifolia* occur around the margin. *Leptospermum polygalifolium* occurs on the landward edge (Stricker & Wall 1995).

Mountain Lagoon sedgeland is not a floodplain wetland but is related to other low nutrient wetlands such as Thirlmere Lakes. It has not been mapped because of its small size.

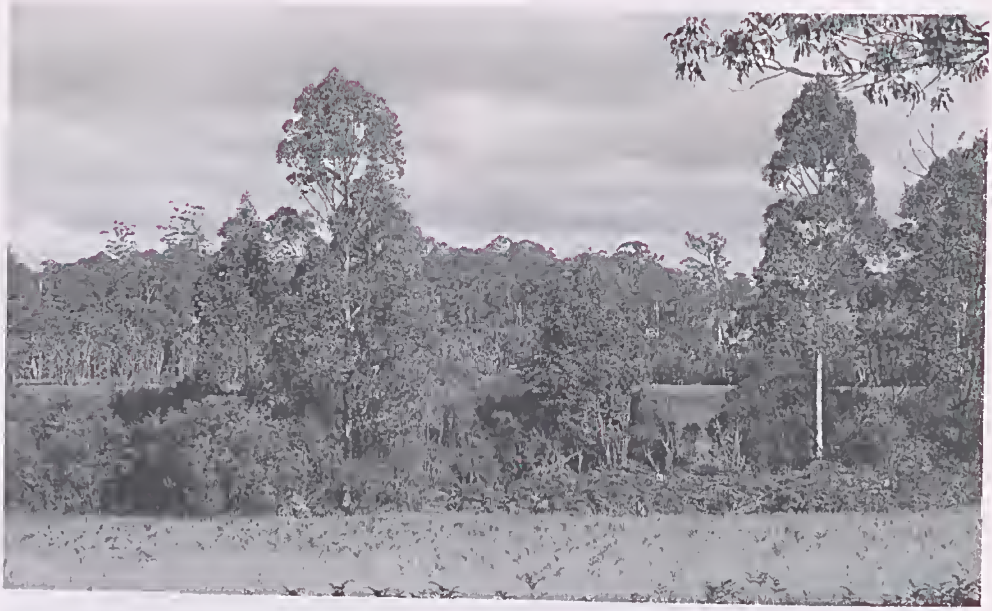

Fig. 13. Interesting sedgeland (Map Unit 28a) with margin of *Melaleuca linariifolia* scrub at Mountain Lagoon.

Discussion

Plant communities

The predominant plant communities for the St Albans map sheet are the Sydney Sandstone Exposed Woodland (map unit 10ar) on ridges and exposed slopes and Sydney Sandstone Gully Forest (map unit 10ag) in gullies and sheltered slopes of the Hawkesbury and Narrabeen group sandstones. These two communities are extensive over the mapped area, the only major interruptions being the sheltered forests of the rivers (map units 9h and 9xc) and the woodlands and swamps of the Mellong Plateau (map units 10m and 27m). The forests of the basalt caps (map unit 6c), the rainforests near Wheeny Creek (map unit 8gr), the forest on the shales (map unit 9a), the communities on alluvium (map units 10af, 20m and 28a) and the Ironbark woodlands of the northern, shaley sandstones all occur on much smaller scales throughout the St Albans 1: 100 000 sheet.

About 700 native species are recorded for the St Albans 1: 100 000 map sheet area (see Appendix 1). Structural and floristic compostion changes with geology and soil, as well as with topographical position and aspect. Fire regimes are an important factor with regard to species biology, ecology and management and distribution of the plant community. The reports compiled by Bell et al. (1993), Sanders et al. (1988) and Maryott–Brown & Wilks (1993) provide a good background for long-term management of these wilderness areas.

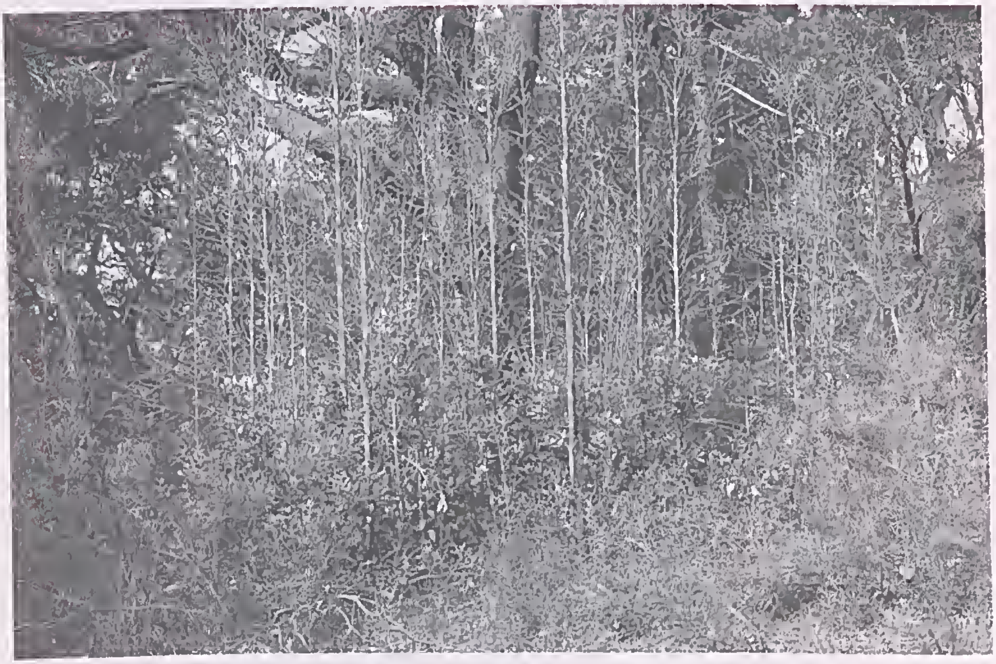

Fig. 14. Although widely found as a medium to large tree, Turpentine, *Syncarpia glomulifera*, also occurs on exposed ridgetops with clay-rich soil as a multi-stemmed mallee-like plant, able to resprout after fire (Map Unit 10ar).

Significant variation in floristic composition may occur within map units and within communities. For the purposes of large-scale mapping, however, it is the dominant trees and shrubs that define a community. For example, studies by National Parks and Wildlife Service (Sanders et al. 1988; Bell et al. 1993) found floristic variation in the understorey of the sandstone ridgetops and so defined two communities on this basis. In their study, Exposed Hawkesbury Sandstone Woodland is distinguished from Exposed Narrabeen Woodland by the presence of *Angophora bakeri, Leptospermum trinervium* and *Lambertia formosa* in the former; and by *Pultenaea microphylla, Persoonia linearis* and *Oxylobium ilicifolium* to the latter. These two communities constitute the single Sydney Sandstone Exposed Woodland (map unit 10ar) in the present study.

The presence of Ironbark eucalypts throughout the sandstone country appears to be related to shale components of the underlying Hawkesbury and Narrabeen Group sandstones. Shale lenses and areas of high shale content are marked by the presence of Ironbarks, together with *Syncarpia glomulifera*. (The species of Ironbark present depends on topographical position.) Bell et al. (1993) and Sanders et al. (1988) found that Ironbarks occur with other typical sandstone species in the centre and northern sections of Yengo National Park, where Narrabeen Group sandstone is common, and described these as part of a separate community, Narrabeen–Hawkesbury Ironbark Forest. The presence of Ironbark species in the sandstone communities could not be consistantly identified on aerial photos and so was not mapped separately. The Ironbarks probably represent a transition of sandstone from the quartz-rich sandstone of the Hawkesbury Group to the Narrabeen Group with an increasing frequency of shaley strata and this gradual transition is reflected by the presence, but not dominance, of Ironbarks. Ironbarks may be an equally dominant canopy species with the species typical of Sydney Sandstone Exposed Woodland (map unit 10ar) and Sydney Sandstone Gully Forest (map unit 10ag).

Conservation

There are a number of communities of conservation significance in the Wheeny Creek area. Rainforest elements occur in Wheeny Creek, Gospers Creek and Cabbage Tree Creek on perched sheltered gullies below escarpments. These are isolated and restricted patches that are easily discernible on air photos as a dense, light-green, even canopy. Gully Rainforest (map unit 8gr) is the southern limit of *Dendrocnide photinophylla*, which occurs in Floyds Scrub, its only occurrence in the Central Coast Botanical Sub-Division, otherwise it is restricted the North Coast Botanical Sub-division. Similar occurrences of rainforest are found in Colo Gorge with open-scrub and woodlands occupying different topographic positions. These are replaced by Sheltered Forest (map unit 9h) in the lower Colo. There are also rainforest pockets in the southeastern corner of the map sheet area in particular in the proposed Dyarrabin Nature Reserve (Douglas 1995).

The distribution of Blue Gums *Eucalyptus deanei* and *Eucalyptus saligna* in the Wheeny Creek area is of interest. In general, *Eucalyptus saligna* is more abundant in coastal areas while *Eucalyptus deanei* is more abundant away from the coast. Further, the two species are separated ecologically; *Eucalyptus deanei* generally occurring on alluvial flats and *Eucalyptus saligna* occurring on both alluvial flats and Tertiary volcanics. The two species occur together around Wheeny Creek.

Mellong Woodland (map unit 10me) and the Mellong Sedgelands (map unit 27me) are of conservation significance because of their restricted occurrences in Yengo and Wollemi National Parks; they are confined to the perched alluvium and silty loams on the Mellong Plateau (Bell et al. 1993) which by its particular nature gives rise to a habitat different to surrounding habitats of the sandstone country (Henry 1987). Also associated with the wide valley flats on perched alluvium on the Mellong Plateau and throughout the Macdonald River valley, is the Rough Barked Apple Woodland (map unit 10af). This community is of high conservation significance as much of the valley flats, which are its habitat, are under freehold tenure and have been cleared or grazed in the past.

Much of the vegetation on the unusual Maroota Sandmass has been cleared and remnants are under continuing pressure from extractive industry, groundwater pumping and agriculture. A regional assessment of the importance of the Maroota Sandmass is urgently required (Douglas 1996).

As the greater part of the St Albans 1: 100 000 map sheet is conserved within the boundaries of Wollemi and Yengo National Parks, the majority of plant communities recognised here, particularly those on the rugged sandstone landscapes, are adequately conserved. However Rough-barked Apple Woodland (map unit 10af) and the communities on the Mellong Plateau (map units 10m and 27m) remain poorly

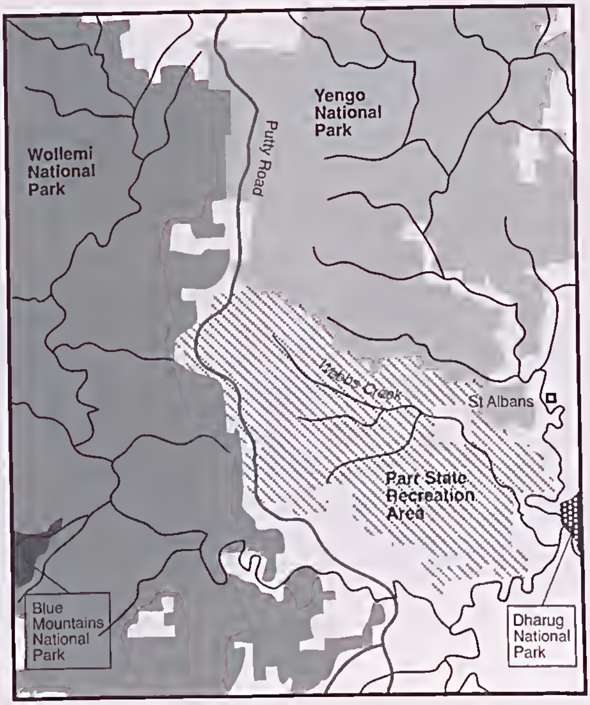

Fig. 15. Major conservation areas for the St Albans map sheet area.

conserved, while plant communities restricted to localised habitats, such as *Melaleuca* Swamp Forest (map unit 20m), are only moderately conserved. Forest communities on shale patches such as *Eucalyptus deanei* at Mountain Lagoon, and Shale Cap Forest (map unit 9a) may also be threatened by clearing for agriculture and increased suburban or rural residential settlement. The proposed Dyarrabin Nature Reserve (Douglas 1995) in the Maroota area would protect important freshwater wetlands such as Jacksons Swamp, Riverflat Forest and Swamp Forest, gullies with rainforest pockets and ridgetops with Mittagong Formation soils and vegetation.

Rare or threatened plant species

Of the 31 significant species listed for the St Albans map sheet, 22 are nationally rare or threatened (ROTAP) species including eight that are vulnerable (Table 4). The area is largely inaccessible and this number is probably an underestimate. Maryott–Brown and Wilks (1993) described the rare and endangered plants of Yengo National Park and nearby areas. Examples of some of these species are:

Acacia pubescens is a vulnerable shrub (2VCa) confined to a few small locations in the Sydney region and the northern Blue Mountains. Within the St Albans map sheet, an isolated population occurs near Mountain Lagoon.

Alania endlicheri is an uncommon herb restricted to the Blue Mountains and Wollemi National Park. On the St Albans sheet, it occurs near Mountain Lagoon and south of the Colo River. It is found in damp spots on rock faces and in sheltered gullies of

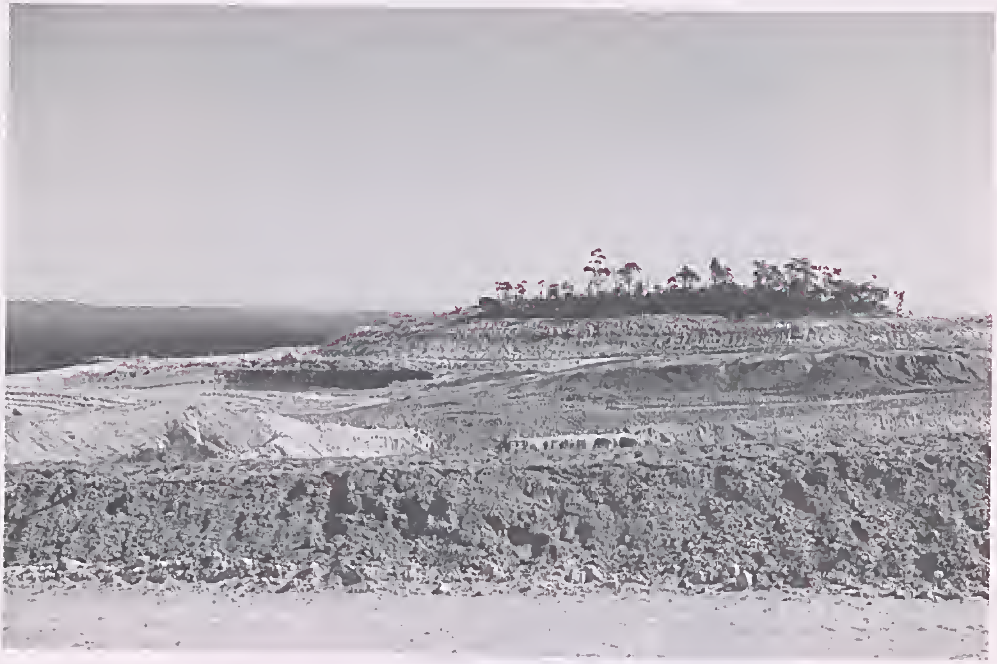

Fig. 16. The Maroota Sandmass complex of heath and woodland includes rare species such as *Acacia bynoeana* and *Kunzea rupestris*, but has been very much reduced in area by sandmining and agriculture (subunit of Map Unit 10ar).

Sydney Sandstone Gully Forest (map unit 10ag) and Narrabeen–Hawkesbury Sheltered Forest (map unit 9h).

Atkinsonia ligustrina is a rare shrub (2RCa) endemic to the Blue Mountains and the Colo Plateau. It is found in the dry open-woodlands of the Culoul Range (map unit 10ar).

Callistemon shiressii is a rare shrub (3RC-) is found in the Colo Valley, Howes Valley, Bulga and Gosford. On the St Albans map sheet, it occurs along the Colo River and Mogo Creek. It is an understorey shrub in the wet sclerophyll forests of Hawkesbury–Narrabeen Sheltered Forest (map unit 9h).

Eucalyptus michaeliana is a rare eucalypt species (3RCa) which is interesting because it has 3 disjunct populations: Yengo National Park; Armidale; and the McPherson Ranges. On the St Albans map sheet, it occurs in the tributaries of the Macdonald valley on the sheltered slopes and creeklines of Hawkesbury–Narrabeen Sheltered Forest (map unit 9h).

Kennedia retrorsa is a vulnerable climbing herb (2VCa) occurring between the Goulburn River and Yengo. On the St Albans sheet, it occurs north of Colo Heights on the deep and enriched gully soils of Sydney Sandstone Gully forest (map unit 10ar).

Lissanthe sapida is a rare shrub (3RCa) found on the Woronora Plateau, in the Blue Mountains and in Wollemi National Park. On the St Albans map sheet, small, isolated populations have also been reported in the Colo Gorge and along the Culoul Range. It is found on the sheltered slopes and gullies of Sydney Sandstone Gully Forest (map unit 10ag).

Lomandra brevis is a rare tussock herb (2RC-) restricted to the Sydney region and its occurence in Yengo National Park is both the most western and northern recording to date. The northern-most location is near Old Settlers Road, which is just off the St Albans sheet (on the Gosford 1: 100 000 sheet). It also occurs on the Womerah Range and Howes Range in damp spots of Sydney Sandstone Ridgetop Woodland (map unit 10ar).

Olearia cordata, a vulnerable shrub (2VCi), occurs in scattered populations between Wisemans Ferry and Wollombi. On the St Albans map sheet, it occurs on the Howes Range, Grassy Hill, Colo River, St Albans and Wisemans Ferry. It is found on exposed slopes or ridges of Sydney Sandstone Ridgetop Woodland (map unit 10ar).

Platysace clelandii is a rare shrub (2RCa) recorded in scattered populations from Berowra to Glen Davis. On the St Albans sheet it occurs on the cliffs above the Colo River, on Wheelbarrow Ridge, Culoul Range and Wisemans Ferry. It is found on the ridges or upper slopes of Sydney Sandstone Ridgetop Woodland (map unit 10ar).

Pomaderris brunnea is a vulnerable shrub (2VC-) confined to the Nepean and Colo Rivers. It is found in both Sydney Sandstone Ridgetop Woodland (map unit 10ar) and Gully Forest (map unit 10ag).

Tetratheca glandulosa is a vulnerable shrub (2VC-) restricted to the Central Coast, north of Port Jackson. On the St Albans map sheet, it occurs near Colo Heights and north of Wheelbarrow Ridge. It is found on the Sydney Sandstone Ridgetop Woodland (map unit 10ar).

Velleia perfoliata is a vulnerable herb (2VC-) found in the Hawkesbury, Goulburn and Hunter Valleys. On the St Albans sheet it occurs north of Colo Heights and west of Upper Colo near the Colo River. It is found in shallow depressions on Hawkesbury Sandstone rock platforms (as it is north of Colo Heights), or under cliffs (as it is in the Colo).

Zieria involucrata is a rare shrub (2RCa) found in the Blue Mountains and in, and near, Yengo National Park. On the St Albans sheet it occurs at Colo Heights, north of Wheelbarrow Ridge, south of Womerah Range and south of Howes Range. It is found on the lower slopes of Hawkesbury Sandstone in Sydney Sandstone Gully Forest (map unit 10ag). A full list of species with particular conservation significance is given in Table 4.

Table 4. Species of particular conservation significance within the St Albans 1: 100 000 map sheet area.

Species listed here are either rare or threatened, or of regional botanical significance in terms of geographic distribution or localised populations disjunct from other occurrences. Localities refer to St Albans map sheet occurrences. Nth = northern, Sth = southern, codes are from Briggs & Leigh (1988, with current ROTAP updatings).

Family/Species	Habitat/Locality (map unit)	Significance (codes refer to Briggs & Leigh 1988)
FERNS		
BLECHNACEAE		
Blechnum indicum	Swamp forest, Leets Vale	Uncommon
DICOTYLEDONS		
APIACEAE		
Platysace clelandii	Woodland, Colo River, Wheelbarrow Ridge, Culoul Range, Wisemans Ferry, Leets Vale (10ar)	2RCa
ASTERACEAE		
Olearia cordata	Woodland, Howes Range, Grassy Hill, Colo River, St Albans, Wisemans Ferry (10ar)	2VCi, local endemic, only 2 pop. known
CABOMBACEAE		
Brasenia schreberi	Lagoons, Colo River (28a)	3RC-+, uncommon
EPACRIDACEAE		
Lissanthe sapida	Woodland, Colo Gorge, Culoul Range (9xc, 10ag)	3RCa
EUPHORBIACEAE		
Omalanthus stillingiifolius	Wheeny Creek (9h)	uncommon
Ricinocarpos bowmanii	Dharug N.P. (10ar, 21j)	E-limit
FABACEAE		
Acacia bynoeana	Scrub, Maroota	3VC-, uncommon
Acacia pubescens	Mountain Lagoon (9a)	2VCa, disjunct pop.
Kennedia retrorsa	Sheltered forests, north of Colo Heights (9a)	2VCa
GOODENIACEAE		
Velleia perfoliata	Rock platforms, Colo River (10ar)	2VC-

Family/Species	Habitat/Locality (map unit)	Significance (codes refer to Briggs & Leigh 1988)
LAMIACEAE		
Prostanthera cineolifera	Open-forest (10ag)	2K
Prostanthera howelliae	Woodland, Sackville	rare
LORANTHACEAE		
Atkinsonia ligustrina	Woodland, Culoul Range, St Albans (10ar)	2RCa
MYRTACEAE		
Callistemon shiressii	Riverbanks, Mogo Creek, Colo River (9h, 10ag)	3RC-
Darwinia biflora	Scrub, Maroota (10ar)	2VCa
Darwinia fascicularis subsp. *oligantha*	Scrub, heath, Maroota (10ar)	disjunct local pop.
Eucalyptus michaeliana	Macdonald valley (9h, 10ag)	3RCa, uncommon
Kunzea rupestris	Heath, Maroota (10ar)	2VCa
Leptospermum spectabile	Rocky sandstone banks, Colo River (8gr, 9xc)	2RC-
Melaleuca deanei	Heath (10ar)	3RC-
PITTOSPORACEAE		
Hymenosporum flavum	Wheeny Creek (8gr, 9h, 9xc, 10ag)	S-limit
PROTEACEAE		
Persoonia hirsuta	Heath, scrub, Sackville, Maroota	3KCi, rare
RHAMNACEAE		
Pomaderris brunnea	Open-forest and woodland, Colo River (9h, 10ar)	2V
RUTACEAE		
Asterolasia elegans	Moist open-forest, Leets Vale, Maroota	2ECi, local endemic
Zieria involucrata	Moist forest, Womerah Range, Howes Range, Wheelbarrow Ridge, Leets Vale, Lower Portland (9h, 10ag)	2RCa
STERCULIACEAE		
Keraudrenia corollata var. *denticulata*	Riverflat forest, Morans Rock, Gees Lagoon	local disjunct pop, southern limit
TREMANDACEAE		
Tetratheca glandulosa	Woodland, scrub, Wheelbarrow Ridge, Maroota, Lower Portland (10ar)	2VC-
URTICACEAE		
Dendrocnide photinophylla	Rainforest, Wheeny Creek (8gr)	S-limit
MONOCOTYLEDONS		
ANTHERICACEAE		
Alania endlicheri	Wet rock-faces and sheltered gullies, Mountain Lagoon	Uncommon
CYPERACEAE		
Cladium procerum	Estuarine vegetation (27a), Webbs Creek	Uncommon
LOMANDRACEAE		
Lomandra brevis	Open-forest, Womerah Range, Howes Range (9h, 10ag)	2RC-

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Appendix 1. Native plant species for communities shown on the St Albans 1: 100 000 vegetation map sheet (key to communities is given in Table 3)

Communities **Species**	**6c**	**8gr**	**9a**	**9h**	**9xc**	**10af**	**10ag**	**10ar**	**10me**	**10ni**	**21j**	**27a**	**27me**	**28a**
FERNS & FERN ALLIES														
Adiantaceae														
Adiantum aethiopicum	6c	8gr		9h	9xc	10af	10ag	10ar		10ni				
Adiantum formosum		8gr		9h	9xc									
Adiantum hispidulum		8gr		9h			10ag							
Adiantum silvaticum		8gr												
Aspidiaceae														
Polystichum australiense		8gr												
Aspleniaceae														
Asplenium attenuatum		8gr												
Asplenium australasicum		8gr												
Asplenium flabellifolium		8gr		9h				10ar						
Asplenium polypodon		8gr												
Athyriaceae														
Diplazium australe		8gr												
Blechnaceae														
Blechnum cartilagineum		8gr	9a	9h	9xc		10ag	10ar						
Blechnum nudum		8gr					10ag							28a
Blechnum patersonii		8gr												
Blechnum wattsii		8gr												
Doodia aspera	6c	8gr		9h			10ag							
Doodia caudata var. *caudata*		8gr		9h										
Cyatheaceae														
Cyathea australis		8gr					10ag							
Cyathea leichhardtiana		8gr												
Davalliaceae														
Arthropteris tenella		8gr												
Davallia pyxidata		8gr												
Dennstaedtiaceae														
Dennstaedtia davallioides		8gr												
Histiopteris incisa		8gr												
Hypolepis muelleri												27a	27me	
Pteridium esculentum	6c		9a						10me					
Dicksoniaceae														
Calochlaena dubia		8gr		9h				10ar						
Dryopteridaceae														
Lastreopsis acuminata		8gr												
Lastreopsis decomposita		8gr												
Lastreopsis microsora		8gr												
Gleicheniaceae														
Gleichenia dicarpa														28a
Sticherus flabellatus					9xc		10ag							
Grammitidaceae														
Grammitis billardieri		8gr												
Hymenophyllaceae														
Hymenophyllum australe		8gr												
Hymenophyllum cupressiforme		8gr												
Macroglena caudata		8gr												

Communities **Species**	**6c**	**8gr**	**9a**	**9h**	**9xc**	**10af**	**10ag**	**10ar**	**10me**	**10ni**	**21j**	**27a**	**27me**	**28a**
Lindsaeaceae														
Lindsaea linearis		8gr					10ag	10ar	10me					
Lindsaea microphylla		8gr		9h			10ag	10ar						
Marsileaceae														
Marsilea mutica														28a
Ophioglossaceae														
Botrychium australe						10af								
Osmundaceae														
Leptopteris fraseri		8gr												
Todea barbara		8gr			9xc		10ag							
Polypodiaceae														
Microsorium scandens		8gr												
Platycerium bifurcatum subsp. *bifurcatum*		8gr												
Pyrrosia rupestris		8gr		9h				10ar						
Psilotaceae														
Tmesipteris ovata		8gr												
Tmesipteris truncata		8gr												
Pteridaceae														
Pteris tremula		8gr												
Pteris umbrosa		8gr												
Schizaeaceae														
Schizaea bifida								10ar						
Schizaea dichotoma		8gr												
Selaginellaceae														
Selaginella uliginosa									10me					
Sinopteridaceae (Adiantaceae)														
Cheilanthes austrotenuifolia				9h										
Cheilanthes distans				9h				10ar						
Cheilanthes sieberi subsp. *sieberi*	6c			9h		10af		10ar						
Pellaea falcata var. *falcata*	6c	8gr		9h			10ag	10ar						
Pellaea falcata var. *nana*		8gr												
Pellaea paradoxa		8gr												
Thelypteridaceae														
Christella dentata							10ag							28a
CYCADS AND CONIFERS														
Zamiaceae														
Macrozamia spiralis								10ar						
Podocarpaceae														
Podocarpus spinulosus				9h				10ar						
DICOTYLEDONS														
Acanthaceae														
Brunoniella pumilio						10af	10ag	10ar						
Pseuderanthemum variabile		8gr		9h		10af	10ag	10ar						
Amaranthaceae														
Alternanthera denticulata												27a		28a
Deeringia amaranthoides		8gr												

Communities **Species**	**6c**	**8gr**	**9a**	**9h**	**9xc**	**10af**	**10ag**	**10ar**	**10me**	**10ni**	**21j**	**27a**	**27me**	**28a**
Apiaceae														
Actinotus helianthi							10ag	10ar			21j			
Actinotus minor								10ar						
Centella asiatica									10me		21j	27a	27me	28a
Daucus glochidiatus	6c													
Hydrocotyle geraniifolia				9h										
Hydrocotyle laxiflora				9h										28a
Hydrocotyle peduncularis					9xc	10af	10ag		10me				27me	28a
Hydrocotyle tripartita					9xc									28a
Hydrocotyle verticillata												27a		
Platysace clelandii				9h	9xc		10ag	10ar		10ni				
Platysace ericoides						10af	10ag	10ar	10me					
Platysace lanceolata				9h	9xc	10af	10ag	10ar						
Platysace linearifolia							10ag	10ar			21j			
Xanthosia atkinsoniana	6c												27me	
Xanthosia pilosa							10ag	10ar						
Xanthosia tridentata							10ag	10ar						
Apocynaceae														
Melodinus australis		8gr												
Parsonsia brownii								10ar						
Parsonsia sp. *A*				9h										
Parsonsia straminea var. *straminea*		8gr												
Parsonsia velutina		8gr												
Araliaceae														
Astrotricha floccosa			9a	9h			10ag	10ar						
Astrotricha latifolia				9h	9xc	10af								
Astrotricha longifolia (inland form)									10ar					
Cephalaralia cephalobotrys		8gr												
Polyscias murrayi		8gr												
Polyscias sambucifolia		8gr	9a	9h		10af	10ag	10ar						28a
Asclepiadaceae														
Marsdenia flavescens		8gr												
Marsdenia suaveolens		8gr			9xc		10ag							
Tylophora barbata		8gr	9a	9h			10ag	10ar						
Asteraceae														
Bracteantha bracteata			9a											
Helichrysum adenophorum var. *waddelliae*										10ni				
Helichrysum elatum		8gr												
Helichrysum scorpioides								10ar		10ni				
Lagenifera stipitata		8gr				10af	10ag	10ar						
Olearia cordata								10ar						
Olearia tomentosa				9h		10af		10ar						
Ozothamnus diosmifolius			9a	9h			10ag	10ar	10me	10ni				
Senecio hispidulus var. *hispidulus*	6c		9a	9h										
Senecio linearifolius		8gr												
Senecio velleioides								10ar						
Sigesbeckia orientalis subsp. *orientalis*		8gr					10ag							
Vernonia cinerea var. *cinera*		8gr						10ar						
Vittadinia sulcata														28a

Communities Species	**6c**	**8gr**	**9a**	**9h**	**9xc**	**10af**	**10ag**	**10ar**	**10me**	**10ni**	**21j**	**27a**	**27me**	**28a**
Baueraceae														
Bauera rubioides									10me					
Bignoniaceae														
Pandorea pandorana		8gr		9h	9xc	10af	10ag	10ar						
Boraginaceae														
Austrocynoglossum australe		8gr												
Austrocynoglossum latifolium		8gr												
Ehretia acuminata var. *acuminata*		8gr												
Cabombaceae														
Brasenia schreberi														28a
Campanulaceae														
Wahlenbergia communis								10ar					27me	
Wahlenbergia gracilis								10ar						
Wahlenbergia stricta subsp. *stricta*						10af		10ar						
Caryophyllaceae														
Stellaria flaccida	6c	8gr		9h		10af						27a		
Casuarinaceae														
Allocasuarina littoralis			9a				10ag	10ar						
Allocasuarina torulosa				9h		10af	10ag	10ar						
Casuarina cunninghamiana subsp. *cunninghamiana*				9h										
Casuarina glauca												27a		28a
Celastraceae														
Maytenus silvestris	6c		9a	9h	9xc		10ag	10ar						
Chloanthaceae														
Chloanthes stoechadis		8gr						10ar						
Clusiaceae														
Hypericum gramineum						10af		10ar						
Hypericum japonicum									10me		21j			
Convolvulaceae														
Calystegia marginata		8gr												
Dichondra repens	6c	8gr		9h		10af	10ag	10ar	10me					28a
Crassulaceae														
Crassula helmsii				9h				10ar						
Crassula sieberiana				9h										
Cucurbitaceae														
Sicyos australis		8gr												
Cunoniaceae														
Aphanopetalum resinosum		8gr												
Callicoma serratifolia		8gr		9h			10ag							
Ceratopetalum apetalum		8gr		9h			10ag							
Ceratopetalum gummiferum				9h	9xc		10ag	10ar						
Schizomeria ovata		8gr												
Dilleniaceae														
Hibbertia acicularis								10ar					27me	
Hibbertia aspera								10ar						
Hibbertia bracteata							10ag	10ar						

Communities **Species**	**6c**	**8gr**	**9a**	**9h**	**9xc**	**10af**	**10ag**	**10ar**	**10me**	**10ni**	**21j**	**27a**	**27me**	**28a**
Hibbertia circumdans								10ar						
Hibbertia dentata		8gr		9h	9xc									
Hibbertia fasciculata									10me					
Hibbertia linearis								10ar						
Hibbertia obtusifolia							10ag	10ar		10ni				
Droseraceae														
Drosera peltata							10ag	10ar	10me					
Ebenaceae														
Diospyros australis		8gr												
Diospyros pentamera		8gr												
Elaeocarpaceae														
Elaeocarpus reticulatus		8gr	9a	9h	9xc	10af	10ag	10ar						
Elatinaceae														
Elatine gratioloides														28a
Epacridaceae														
Acrotriche aggregata							10ag	10ar						
Acrotriche divaricata					9xc									
Brachyloma daphnoides				9h				10ar	10me					
Dracophyllum secundum		8gr			9xc									
Epacris microphylla var. *microphylla*							10ag							
Epacris pulchella						10af	10ag	10ar						
Epacris purpurascens var. *purpurascens*								10ar						
Leucopogon appressus								10ar			21j			
Leucopogon ericoides											21j			
Leucopogon fletcheri subsp. *fletcheri*								10ar						
Leucopogon juniperinus								10ar		10ni				
Leucopogon lanceolatus var. *lanceolatus*		8gr	9a	9h	9xc		10ag	10ar						
Leucopogon microphyllus var. *microphyllus*								10ar						
Leucopogon muticus				9h			10ag	10ar	10me	10ni				
Leucopogon setiger				9h				10ar		10ni				
Leucopogon virgatus													27me	
Lissanthe sapida					9xc			10ar						
Lissanthe strigosa subsp. *strigosa*								10ar		10ni				
Melichrus procumbens								10ar					27me	
Monotoca scoparia				9h			10ag	10ar	10me		21j			
Styphelia laeta subsp. *laeta*								10ar		10ni				
Trochocarpa laurina		8gr					10ag							
Woollsia pungens							10ag							
Escalloniaceae														
Abrophyllum ornans		8gr												
Euphorbiaceae														
Amperea xiphoclada							10ag	10ar						
Breynia oblongifolia	6c	8gr	9a	9h			10ag	10ar						
Claoxylon australe		8gr												
Glochidion ferdinandi var. *ferdinandi*				9h	9xc		10ag	10ar						

Communities **Species**	**6c**	**8gr**	**9a**	**9h**	**9xc**	**10af**	**10ag**	**10ar**	**10me**	**10ni**	**21j**	**27a**	**27me**	**28a**
Micrantheum ericoides								10ar						
Omalanthus nutans		8gr												
Omalanthus stillingifolius				9h										
Phyllanthus gasstroemii				9h	9xc									
Phyllanthus hirtellus							10ag	10ar		10ni	21j			
Poranthera ericifolia								10ar						
Poranthera microphylla						10af	10ag	10ar						
Pseudanthus pimeleoides								10ar						
Ricinocarpos bowmannii								10ar			21j			
Ricinocarpos pinifolius								10ar						
Eupomatiaceae														
Eupomatia laurina		8gr												
Fabaceae – Faboideae														
Aotus ericoides	6c						10ag		10me	10ni				
Bossiaea ensata								10ar			21j			
Bossiaea heterophylla							10ag	10ar	10me		21j			
Bossiaea lenticularis								10ar						
Bossiaea obcordata				9h			10ag	10ar						
Bossiaea rhombifolia subsp. *rhombifolia*							10ag	10ar						
Bossiaea scolopendria								10ar						
Daviesia acicularis								10ar	10me				27me	
Daviesia alata													27me	
Daviesia corymbosa							10ag	10ar						
Daviesia squarrosa								10ar						
Daviesia ulicifolia							10ag	10ar		10ni				
Desmodium rhytidophyllum				9h				10ar						
Desmodium varians			9a	9h		10af		10ar						
Dillwynia acicularis								10ar		10ni				
Dillwynia floribunda								10ar						
Dillwynia floribunda var. *teretifolia*							10ag	10ar			21j			
Dillwynia glaberrima									10me				27me	
Dillwynia retorta							10ag	10ar						
Dillwynia sericea							10ag	10ar					27me	
Glycine clandestina				9h		10af	10ag	10ar						
Glycine microphylla	6c		9a			10af		10ar						
Glycine tabacina				9h		10af								
Gompholobium glabratum								10ar	10me					
Gompholobium grandiflorum							10ag	10ar						
Gompholobium latifolium				9h	9xc		10ag	10ar	10me					
Gompholobium pinnatum							10ag		10me					
Gompholobium virgatum var. *aspalathoides*							10ag	10ar						
Hardenbergia violacea			9a	9h		10af	10ag	10ar		10ni				
Hovea linearis							10ag	10ar		10ni				
Hovea longifolia				9h	9xc			10ar						
Indigofera australis	6c		9a	9h				10ar						
Jacksonia scoparia								10ar						
Kennedia prostrata							10ag							
Kennedia retrorsa			9a											
Kennedia rubicunda	6c		9a	9h				10ar						

Communities **Species**	**6c**	**8gr**	**9a**	**9h**	**9xc**	**10af**	**10ag**	**10ar**	**10me**	**10ni**	**21j**	**27a**	**27me**	**28a**
Mirbelia rubiifolia								10ar	10me					
Mirbelia speciosa subsp. *speciosa*								10ar			21j			
Phyllota phylicoides								10ar						
Platylobium formosum							10ag							
Podolobium aciculiferum								10ar						
Podolobium ilicifolium			9a	9h	9xc	10af	10ag	10ar		10ni				
Pultenaea cunninghamii								10ar		10ni				
Pultenaea daphnoides							10ag			10ni				
Pultenaea echinula								10ar						
Pultenaea elliptica			9a					10ar			21j			
Pultenaea ferruginea var. *ferruginea*							10ag	10ar						
Pultenaea flexilis			9a			10af	10ag	10ar						
Pultenaea scabra							10ag	10ar		10ni				
Pultenaea villosa								10ar						
Sphaerolobium vimineum									10me					
Viminaria juncea													27me	
Fabaceae – Mimosoideae														
Acacia binervata				9h										
Acacia binervia								10ar						
Acacia brownii							10ag	10ar	10me				27me	
Acacia buxifolia subsp. *buxifolia*								10ar		10ni				
Acacia echinula							10ag	10ar						
Acacia elata		8gr			9xc		10ag							
Acacia elongata var. *elongata*				9h										
Acacia falcata			9a					10ar		10ni				
Acacia filicifolia				9h		10af		10ar					27me	28a
Acacia floribunda				9h	9xc		10ag							
Acacia hispidula							10ag	10ar						
Acacia implexa				9h			10ag	10ar		10ni				
Acacia linifolia				9h	9xc		10ag	10ar	10me					
Acacia longifolia			9a	9h		10af		10ar						
Acacia myrtifolia							10ag	10ar						
Acacia obtusifolia				9h	9xc									
Acacia paradoxa			9a			10af								
Acacia parramattensis	6c		9a			10af	10ag	10ar		10ni	21j			
Acacia parvipinnula				9h	9xc		10ag	10ar		10ni				
Acacia penninervis							10ag	10ar		10ni			27me	
Acacia pubescens			9a											
Acacia saliciformis				9h			10ag	10ar	10me	10ni				
Acacia schinoides				9h										
Acacia suaveolens							10ag	10ar			21j			
Acacia terminalis							10ag	10ar						
Acacia ulicifolia				9h	9xc		10ag	10ar	10me					
Acacia uncinata								10ar						
Geraniaceae														
Geranium homeanum		8gr												
Geranium neglectum				9h										
Geranium solanderi var. *solanderi*	6c		9a	9h										

Communities **Species**	**6c**	**8gr**	**9a**	**9h**	**9xc**	**10af**	**10ag**	**10ar**	**10me**	**10ni**	**21j**	**27a**	**27me**	**28a**
Gesneriaceae														
Fieldia australis		8gr												
Goodeniaceae														
Coopernookia barbata								10ar						
Dampiera stricta							10ag	10ar	10me		21j			
Goodenia bellidifolia subsp. *bellidifolia*								10ar						
Goodenia decurrens							10ag							
Goodenia hederacea subsp. *hederacea*								10ar						
Goodenia heterophylla subsp. *heterophylla*							10ag	10ar						
Goodenia ovata			9a				10ag	10ar						
Goodenia paniculata									10me				27me	
Scaevola ramosissima								10ar						
Velleia perfoliata								10ar						
Haloragaceae														
Gonocarpus micranthus subsp. *micranthus*									10me				27me	
Gonocarpus tetragynus			9a	9h		10af	10ag	10ar						
Gonocarpus teucrioides				9h	9xc		10ag	10ar						
Haloragis heterophylla									10me				27me	
Myriophyllum latifolium														28a
Lamiaceae														
Ajuga australis											21j			
Hemigenia purpurea								10ar	10me					
Lycopus australis												27a		
Plectranthus parviflorus	6c	8gr	9a	9h				10ar						
Prostanthera incisa							10ag							
Prostanthera lasianthos	6c													
Prostanthera linearis					9xc									
Prostanthera ovalifolia s. lat.		8gr		9h			10ag							
Prostanthera prunelloides				9h	9xc									
Prostanthera rhombea		8gr												
Lauraceae														
Cassytha pubescens						10af			10me					
Cryptocarya glaucescens		8gr												
Neolitsea dealbata		8gr												
Lentibulariaceae														
Utricularia dichotoma													27me	
Utricularia gibba														28a
Lobeliaceae														
Lobelia dentata							10ag							
Pratia purpurascens	6c	8gr	9a	9h		10af	10ag	10ar	10me		21j			28a
Loganiaceae														
Logania albiflora							10ag	10ar						
Mitrasacme polymorpha							10ag	10ar	10me					
Loranthaceae														
Atkinsonia ligustrina								10ar						
Malvaceae														
Abutilon oxycarpum		8gr												
Hibiscus heterophyllus subsp. *heterophyllus*				9h										

Communities **Species**	**6c**	**8gr**	**9a**	**9h**	**9xc**	**10af**	**10ag**	**10ar**	**10me**	**10ni**	**21j**	**27a**	**27me**	**28a**
Meliaceae														
Melia azedarach		8gr												
Toona ciliata		8gr												
Menispermaceae														
Sarcopetalum harveyanum		8gr		9h	9xc		10ag							
Stephania japonica var. *discolor*		8gr		9h	9xc		10ag							
Monimiaceae														
Doryphora sassafras		8gr												
Hedycarya angustifolia		8gr												
Palmeria scandens		8gr												
Wilkiea huegeliana		8gr												
Moraceae														
Ficus coronata		8gr					10ag							
Ficus rubiginosa		8gr		9h										
Ficus superba var. *henneana*		8gr												
Myrsinaceae														
Rapanea howittiana		8gr		9h			10ag							
Rapanea variabilis	6c	8gr	9a	9h	9xc			10ar						
Myrtaceae														
Acmena smithii		8gr					10ag							
Angophora bakeri							10ag	10ar	10me		21j			
Angophora costata						10af	10ag	10ar	10me		21j			
Angophora euryphylla								10ar						
Angophora floribunda				9h		10af	10ag	10ar			21j			
Angophora hispida								10ar			21j			
Backhousia myrtifolia		8gr		9h	9xc	10af	10ag	10ar						
Baeckea densifolia								10ar						
Baeckea diosmifolia								10ar	10me				27me	
Baeckea virgata					9xc			10ar						
Callistemon citrinus									10me		21j		27me	28a
Callistemon linearifolius					9xc									
Callistemon pallidus					9xc						21j			
Callistemon salignus				9h				10ar						
Callistemon shiressii				9h			10ag							
Calytrix tetragona								10ar						
Choricarpia leptopetala		8gr					10ag							
Corymbia eximia							10ag	10ar		10ni				
Corymbia gummifera						10af	10ag	10ar						
Darwinia biflora								10ar						
Darwinia fascicularis subsp. *oligantha*								10ar						
Eucalyptus agglomerata					9xc	10af	10ag							
Eucalyptus amplifolia subsp. *amplifolia*						10af								
Eucalyptus beyeriana								10ar		10ni	21j			
Eucalyptus capitellata								10ar						
Eucalyptus crebra	6c		9a	9h				10ar		10ni	21j			
Eucalyptus cypellocarpa			9a											
Eucalyptus deanei	6c		9a	9h	9xc									
Eucalyptus eugenioides			9a											
Eucalyptus fergusonii subsp. *dorsiventralis*										10ni				

Communities **Species**	**6c**	**8gr**	**9a**	**9h**	**9xc**	**10af**	**10ag**	**10ar**	**10me**	**10ni**	**21j**	**27a**	**27me**	**28a**
Eucalyptus fibrosa								10ar		10ni	21j			
Eucalyptus globoidea	6c		9a					10ar						
Eucalyptus haemastoma								10ar	10me					
Eucalyptus michaeliana				9h				10ar		10ni				
Eucalyptus notabilis								10ar						
Eucalyptus paniculata subsp. *paniculata*	6c		9a			10af	10ag							
Eucalyptus parramattensis subsp. *parramattensis*									10me		21j			
Eucalyptus pilularis								10ar						
Eucalyptus piperita			9a	9h		10af	10ag	10ar						
Eucalyptus prominula								10ar						
Eucalyptus punctata	6c		9a	9h	9xc	10af	10ag	10ar						
Eucalyptus resinifera subsp. *resinifera*						10af								
Eucalyptus robusta												27a		
Eucalyptus saligna				9h		10af	10ag	10ar						
Eucalyptus sclerophylla						10af			10me					
Eucalyptus siderophloia								10ar						
Eucalyptus sparsifolia								10ar			21j			
Eucalyptus squamosa								10ar						
Eucalyptus tereticornis						10af			10me		21j		27me	
Kunzea ambigua								10ar						
Kunzea capitata								10ar						
Kunzea rupestris								10ar						
Leptospermum continentale														28a
Leptospermum juniperinum									10me		21j		27me	
Leptospermum lanigerum								10ar						
Leptospermum parvifolium								10ar					27me	
Leptospermum polygalifolium				9h	9xc		10ag	10ar	10me					28a
Leptospermum spectabile		8gr			9xc									
Leptospermum squarrosum													27me	
Leptospermum trinervium							10ag	10ar	10me		21j			
Melaleuca deanei								10ar						
Melaleuca ericifolia												27a		28a
Melaleuca linariifolia									10me		21j	27a	27me	28a
Melaleuca thymifolia						10af			10me		21j		27me	
Micromyrtus ciliata								10ar						
Rhodamnia rubescens		8gr												
Syncarpia glomulifera		8gr	9a	9h	9xc		10ag	10ar						
Tristaniopsis laurina		8gr		9h	9xc		10ag	10ar						
Olacaceae														
Olax stricta								10ar						
Oleaceae														
Notelaea longifolia	6c	8gr		9h	9xc	10af		10ar						
Notelaea ovata		8gr												
Notelaea venosa	6c	8gr	9a	9h										
Onagraceae														
Ludwigia peploides subsp. *montevidensis*														28a
Passifloraceae														
Passiflora cinnabarina		8gr												
Passiflora herbertiana subsp. *herbertiana*		8gr												

Communities **Species**	**6c**	**8gr**	**9a**	**9h**	**9xc**	**10af**	**10ag**	**10ar**	**10me**	**10ni**	**21j**	**27a**	**27me**	**28a**
Peperomiaceae														
Peperomia tetraphylla		8gr												
Piperaceae														
Piper novae-hollandiae		8gr												
Pittosporaceae														
Billardiera scandens var. *scandens*			9a	9h		10af	10ag	10ar		10ni				
Bursaria spinosa var. *spinosa*			9a	9h	9xc	10af	10ag	10ar						
Citriobatus pauciflorus		8gr		9h	9xc		10ag							
Hymenosporum flavum		8gr		9h			10ag							
Pittosporum revolutum		8gr	9a	9h		10af	10ag	10ar						
Pittosporum undulatum		8gr												
Plantaginaceae														
Plantago debilis	6c													
Polygalaceae														
Comesperma ericinum							10ag	10ar						
Comesperma volubile								10ar						
Polygonaceae														
Persicaria decipiens														28a
Persicaria hydropiper												27a		28a
Persicaria lapathifolia														28a
Persicaria praetermissa												27a		28a
Persicaria strigosa												27a		28a
Proteaceae														
Banksia ericifolia var. *ericifolia*								10ar						
Banksia oblongifolia								10ar			21j			
Banksia paludosa								10ar						
Banksia serrata							10ag	10ar	10me					
Banksia spinulosa var. *collina*							10ag	10ar						
Banksia spinulosa var. *spinulosa*						10af	10ag	10ar	10me		21j			
Conospermum longifolium subsp. *longifolium*							10ag	10ar			21j			
Conospermum taxifolium													27me	
Grevillea arenaria						10af								
Grevillea buxifolia subsp. *buxifolia*							10ag	10ar						
Grevillea buxifolia subsp. *phylicoides*								10ar						
Grevillea buxifolia subsp. *sphacelata*											21j			
Grevillea mucronulata				9h		10af	10ag	10ar	10me	10ni				
Grevillea oleoides									10me					
Grevillea sericea								10ar					27me	
Grevillea speciosa								10ar						
Hakea dactyloides					9xc	10af	10ag	10ar	10me		21j			
Hakea sericea								10ar						
Isopogon anemonifolius							10ag	10ar	10me		21j			
Isopogon dawsonii				9h										
Lambertia formosa							10ag	10ar	10me		21j			
Lomatia myricoides		8gr		9h	9xc		10ag							
Lomatia silaifolia				9h			10ag	10ar						
Persoonia lanceolata							10ag							
Persoonia levis							10ag	10ar			21j			

Communities **Species**	**6c**	**8gr**	**9a**	**9h**	**9xc**	**10af**	**10ag**	**10ar**	**10me**	**10ni**	**21j**	**27a**	**27me**	**28a**
Persoonia linearis			9a	9h	9xc	10af	10ag	10ar	10me	10ni				
Persoonia oblongata						10af	10ag	10ar	10me				27me	
Persoonia pinifolia								10ar						
Petrophile pulchella								10ar			21j			
Stenocarpus salignus		8gr		9h	9xc	10af		10ar						
Telopea speciosissima							10ag							
Xylomelum pyriforme							10ag	10ar						
Ranunculaceae														
Clematis aristata		8gr	9a	9h			10ag	10ar						
Clematis glycinoides	6c		9a		9xc			10ar						
Ranunculus inundatus									10me		21j	27a	27me	28a
Ranunculus lappaceus	6c													28a
Ranunculus plebeius						10af						27a		28a
Rhamnaceae														
Alphitonia excelsa		8gr												
Cryptandra amara var. *amara*								10ar						
Cryptandra spinescens									10me					
Pomaderris aspera					9xc									
Pomaderris brunnea				9h				10ar						
Pomaderris ferruginea				9h										
Pomaderris intermedia								10ar						
Rosaceae														
Rubus hillii		8gr		9h			10ag							
Rubus parvifolius	6c	8gr			9xc	10af								
Rubus rosifolius		8gr												
Rubus sp. *A*		8gr												
Rubiaceae														
Canthium coprosmoides		8gr												
Galium binifolium			9a	9h			10ag	10ar						
Galium gaudichaudii				9h										
Galium propinquum						10af	10ag							
Morinda jasminoides		8gr		9h	9xc		10ag							
Opercularia aspera				9h				10ar						
Opercularia diphylla						10af								
Pomax umbellata	6c		9a	9h			10ag	10ar	10me	10ni				
Psychotria loniceroides		8gr												
Rutaceae														
Acronychia oblongifolia		8gr												
Asterolasia correifolia				9h										
Asterolasia elegans							10ag							
Boronia anemonifolia var. *anemonifolia*							10ag							
Boronia floribunda								10ar						
Boronia ledifolia							10ag	10ar					27me	
Boronia parviflora									10me					
Boronia pinnata								10ar						
Correa reflexa				9h				10ar						
Eriostemon hispidulus				9h			10ag	10ar	10me					
Eriostemon myoporoides				9h	9xc									
Melicope micrococca		8gr		9h			10ag							
Phebalium dentatum				9h	9xc			10ar						

Communities **Species**	**6c**	**8gr**	**9a**	**9h**	**9xc**	**10af**	**10ag**	**10ar**	**10me**	**10ni**	**21j**	**27a**	**27me**	**28a**
Phebalium squamulosum subsp. *argenteum*						10af					21j			
Phebalium squamulosum subsp. *squamulosum*					9xc		10ag	10ar						
Philotheca salsolifolia								10ar						
Zieria cytisoides				9h										
Zieria involucrata				9h			10ag	10ar						
Zieria pilosa								10ar						
Zieria smithii subsp. *A*		8gr		9h				10ar						
Sambucaceae														
Sambucus australasica		8gr												
Santalaceae														
Choretrum pauciflorum								10ar						
Exocarpos cupressiformis			9a	9h						10ni				
Exocarpos strictus	6c		9a	9h			10ag	10ar		10ni				
Leptomeria acida						10af		10ar						
Sapindaceae														
Dodonaea camfieldii							10ag	10ar						
Dodonaea pinnata								10ar						
Dodonaea triquetra				9h	9xc		10ag	10ar						
Dodonaea viscosa				9h				10ar						
Guioa semiglauca		8gr												
Scrophulariaceae														
Gratiola pedunculata														28a
Veronica plebeia		8gr	9a	9h		10af		10ar						
Solanaceae														
Duboisia myoporoides		8gr		9h										
Solanum aviculare		8gr												
Solanum prinophyllum	6c	8gr	9a			10af								
Solanum pungetium				9h			10ag							
Stackhousiaceae														
Stackhousia viminea							10ag	10ar						
Sterculiaceae														
Commersonia fraseri				9h	9xc									
Lasiopetalum ferrugineum var. *ferrugineum*					9xc			10ar			21j			
Lasiopetalum macrophyllum					9xc									
Rulingia dasyphylla			9a					10ar						
Stylidiaceae														
Stylidium graminifolium							10ag	10ar	10me					
Stylidium lineare									10me					
Stylidium productum				9h	9xc		10ag	10ar						
Symplocaceae														
Symplocos thwaitesii		8gr												
Thymelaeaceae														
Pimelea linifolia subsp. *linifolia*				9h			10ag	10ar	10me		21j		27me	
Tremandraceae														
Tetratheca glandulosa								10ar						
Ulmaceae														
Trema aspera		8gr		9h	9xc			10ar						

Communities **Species**	**6c**	**8gr**	**9a**	**9h**	**9xc**	**10af**	**10ag**	**10ar**	**10me**	**10ni**	**21j**	**27a**	**27me**	**28a**
Urticaceae														
Dendrocnide photinophylla		8gr												
Urtica incisa	6c	8gr												
Verbenaceae														
Clerodendrum tomentosum		8gr												
Violaceae														
Hybanthus monopetalus				9h				10ar	10me					
Hymenanthera dentata		8gr												
Viola betonicifolia						10af								
Viola hederacea	6c	8gr		9h	9xc	10af	10ag		10me					28a
Vitaceae														
Cayratia clematidea		8gr												
Cissus antarctica		8gr		9h			10ag							
Cissus hypoglauca		8gr		9h	9xc		10ag							
Winteraceae														
Tasmannia insipida		8gr												
MONOCOTYLEDONS														
Alismataceae														
Alisma plantago-aquatica														28a
Anthericaceae (Liliaceae)														
Arthropodium milleflorum						10af								
Laxmannia gracilis								10ar			21j			
Araceae														
Gymnostachys anceps		8gr		9h			10ag							
Arecaceae														
Livistona australis		8gr												
Asteliaceae														
Cordyline stricta		8gr												
Colchicaceae (Liliaceae)														
Burchardia umbellata									10me				27me	
Commelinaceae														
Commelina cyanea		8gr												
Cyperaceae														
Baumea acuta									10me				27me	
Baumea rubiginosa									10me				27me	
Baumea tetragona														28a
Carex appressa								10ar	10me			27a	27me	28a
Caustis flexuosa							10ag	10ar			21j			
Cladium procerum												27a		28a
Cyathochaeta diandra								10ar	10me				27me	
Cyperus difformis														28a
Cyperus flaccidus														28a
Cyperus polystachyos												27a		28a
Eleocharis equisetina												27a		28a
Eleocharis sphacelata											21j		27me	28a
Fimbristylis dichotoma														28a
Gahnia aspera					9xc			10ar						
Gahnia clarkei								10ar						

Communities **Species**	**6c**	**8gr**	**9a**	**9h**	**9xc**	**10af**	**10ag**	**10ar**	**10me**	**10ni**	**21j**	**27a**	**27me**	**28a**
Gahnia melanocarpa		8gr												
Gahnia sieberiana							10ag							28a
Isolepis inundata						10af					21j	27a	27me	
Lepidosperma filiforme							10ag							
Lepidosperma gunnii							10ag							
Lepidosperma laterale	6c			9h	9xc	10af	10ag	10ar						
Lepidosperma urophorum				9h										
Ptilothrix deusta								10ar	10me		21j		27me	
Schoenoplectus mucronatus														28a
Schoenoplectus validus												27a		28a
Schoenus apogon									10me					
Schoenus brevifolius									10me				27me	
Schoenus ericetorum													27me	
Schoenus imberbis								10ar			21j			
Schoenus maschalinus														28a
Schoenus melanostachys					9xc		10ag	10ar						
Schoenus villosus								10ar					27me	
Haemodoraceae														
Haemodorum planifolium								10ar	10me					
Hydrocharitaceae														
Ottelia ovalifolia														28a
Vallisneria gigantea														28a
Iridaceae														
Libertia paniculata					9xc									
Patersonia glabrata							10ag	10ar						
Patersonia longifolia								10ar					27me	
Patersonia sericea							10ag	10ar			21j			
Juncaceae														
Juncus continuus									10me		21j		27me	
Juncus kraussii subsp. *australiensis*												27a		
Juncus planifolius									10me					
Juncus prismatocarpus													27me	28a
Juncus usitatus												27a		28a
Juncaginaceae														
Triglochin procerum												27a		28a
Triglochin striatum														28a
Lomandraceae														
Lomandra brevis				9h			10ag							
Lomandra cylindrica							10ag	10ar						
Lomandra filiformis subsp. *coriacea*								10ar						
Lomandra filiformis subsp. *filiformis*			9a											
Lomandra glauca							10ag	10ar			21j			
Lomandra longifolia	6c		9a	9h	9xc	10af	10ag	10ar	10me	10ni				
Lomandra multiflora			9a				10ag	10ar						
Lomandra obliqua							10ag	10ar			21j			
Luzuriagaceae (Philesiaceae)														
Eustrephus latifolius		8gr	9a	9h		10af		10ar						
Geitonoplesium cymosum	6c		9a	9h			10ag							

Communities **Species**	**6c**	**8gr**	**9a**	**9h**	**9xc**	**10af**	**10ag**	**10ar**	**10me**	**10ni**	**21j**	**27a**	**27me**	**28a**
Najadaceae														
Najas tenuifolia														28a
Orchidaceae														
Acianthus exsertus		8gr												
Orchidaceae														
Bulbophyllum exiguum		8gr												
Bulbophyllum shepherdii		8gr												
Caladenia carnea var. *carnea*								10ar						
Caladenia catenata								10ar						
Calanthe triplicata		8gr												
Chiloglottis reflexa		8gr												
Corybas aconitoflorus		8gr												
Corybas pruinosus		8gr												
Cymbidium suave					9xc									
Dendrobium aemulum		8gr		9h										
Dendrobium linguiforme var. *linguiforme*		8gr												
Dendrobium pugioniforme		8gr												
Dendrobium speciosum var. *speciosum*				9h										
Dendrobium striolatum		8gr		9h										
Dendrobium teretifolium var. *teretifolium*		8gr												
Dipodium punctatum								10ar						
Liparis reflexa		8gr		9h										
Plectorrhiza tridentata		8gr												
Pterostylis concinna								10ar						
Pterostylis curta	6c							10ar						
Pterostylis longifolia			9a				10ag	10ar						
Pterostylis nutans							10ag	10ar						
Pterostylis parviflora								10ar						
Sarcochilus falcatus		8gr												
Sarcochilus hillii		8gr												
Sarcochilus olivaceus		8gr												
Thelymitra ixioides var. *ixioides*								10ar						
Philydraceae														
Philydrum lanuginosum											21j		27me	28a
Phormiaceae (Liliaceae)														
Dianella caerulea var. *caerulea*		8gr	9a	9h	9xc	10af	10ag	10ar	10me	10ni				
Dianella caerulea var. *producta*	6c		9a				10ag							
Dianella longifolia var. *longifolia*									10me					
Dianella prunina								10ar						
Dianella revoluta			9a				10ag	10ar		10ni				
Stypandra glauca				9h	9xc		10ag	10ar						
Poaceae														
Anisopogon avenaceus							10ag	10ar						
Aristida benthamii var. *spinulifera*								10ar						
Aristida calycina var. *calycina*									10me					
Aristida vagans								10ar						
Aristida warburgii									10me					
Cleistochloa rigida								10ar						

Communities Species	6c	8gr	9a	9h	9xc	10af	10ag	10ar	10me	10ni	21j	27a	27me	28a
Cymbopogon refractus								10ar						
Deyeuxia nudiflora								10ar						
Deyeuxia quadriseta													27me	
Dichelachne micrantha								10ar	10me					
Dichelachne rara			9a				10ag	10ar						
Digitaria breviglumis				9h				10ar						
Echinopogon caespitosus var. *caespitosus*	6c		9a				10ag	10ar						
Echinopogon ovatus			9a											
Entolasia marginata				9h	9xc		10ag	10ar	10me				27me	28a
Entolasia stricta					9xc	10af	10ag	10ar	10me	10ni	21j		27me	
Entolasia whiteana								10ar						
Eragrostis benthamii								10ar						
Eragrostis brownii								10ar	10me				27me	
Hemarthria uncinata var. *uncinata*							10ag					27a		
Hierochloe rariflora				9h										
Imperata cylindrica var. *major*	6c		9a	9h		10af	10ag	10ar	10me				27me	
Microlaena stipoides var. *stipoides*			9a		9xc		10ag	10ar						28a
Oplismenus aemulus		8gr												
Panicum bisulcatum												27a		28a
Panicum obseptum												27a		28a
Panicum simile			9a	9h		10af	10ag	10ar						28a
Paspalidium aversum		8gr												
Paspalum distichum														28a
Phragmites australis												27a	27me	28a
Poa affinis			9a		9xc			10ar						
Stipa ramosissima		8gr		9h	9xc		10ag							
Stipa rudis subsp. *rudis*											21j			
Tetrarrhena juncea							10ag							
Themeda australis						10af	10ag	10ar	10me	10ni				
Potamogetonaceae														
Potamogeton pectinatus														28a
Potamogeton tricarinatus														28a
Restionaceae														
Leptocarpus tenax									10me				27me	
Lepyrodia muelleri									10me				27me	
Lepyrodia scariosa								10ar	10me				27me	
Restio fimbriatus									10me					
Ripogonaceae (Smilacaceae)														
Ripogonum album		8gr												
Smilacaceae														
Smilax australis	6c	8gr	9a	9h	9xc	10af	10ag	10ar						
Smilax glyciphylla		8gr		9h	9xc		10ag	10ar						
Typhaceae														
Typha orientalis												27a		28a
Uvulariaceae (Liliaceae)														
Schelhammera undulata				9h	9xc		10ag	10ar						
Xanthorrhoeaceae														
Xanthorrhoea arborea			9a				10ag	10ar						
Xanthorrhoea media				9h				10ar			21j		27me	
Xanthorrhoea resinifera								10ar						

The floristics and structure of dry rainforest at Forty Mile Scrub National Park, north Queensland

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Fensham, R.J. (Queensland Herbarium, Queensland Department of Environment and Heritage, Meiers Road, Indooroopilly Qld 4068) 1995. The floristics and structure of dry rainforest at Forty Mile Scrub National Park, north Queensland. Cunninghamia *4(3): 483–495.* The floristics and structure of those areas of dry rainforest in a relatively natural condition at Forty Mile Scrub National Park (18°08'S 144°50'E) 140 km west of Cardwell, north Queensland are described. Trees make up about 36% of the 151 native taxa. *Notelaea microcarpa* is the dominant tree throughout most of the forest and *Alectryon connatus*, *Austromyrtus* sp. (Forty Mile Scrub, G.C. Stocker–Coll No. 1785), *Geijera salicifolia* and *Strychnos psilosperma* are also prominent tree species in the continuous tree canopy at 5–7 m height. Emergent trees are sparse.

The stand structure of the dominant tree species in dry rainforest is characterised by a general lack of small size classes and it is suggested that recruitment of seedlings may be a phasic event coinciding with a series of wet years.

Introduction

Rainforest-related vegetation occurs in Australia under climatic regimes that ensure seasonally dry substrates for extended periods. Despite the apparent contradiction this vegetation is included within the 'rainforest' umbrella by virtue of the following features (see Fensham 1995):

1) closed canopy on well-soiled substrates
2) very sparse herbaceous layer
3) plants with taxonomic affinities to rainforest of high rainfall environments
4) mixed tree species dominance
5) fire retardance and sensitivity

The National Rainforest Conservation Programme has funded a recent wave of research directed towards broadscale plant and animal survey, functional ecology, autecology of individual species and conservation assessment of dry rainforest of the eastern seaboard and the monsoon rainforests of northern Australia (see McKenzie et al. 1991; Bowman 1992; Fensham 1995 for references). Despite the plethora of recent publications only Russell-Smith et al. (1993) provide a detailed description of a single rainforest type and none of these studies provides a description of the structure and floristics of an individual rainforest area.

Study area

Forty Mile Scrub National Park, 18°08'S 144°50'E, approximately 140 km due west from the coastal town of Cardwell in north Queensland (Fig. 1) is a classic example of inland dry rainforest vegetation (Webb & Tracey 1981; Stocker & Unwin 1986). Forty Mile Scrub National Park includes one of the larger areas of the fragmented dry rainforest archipelago in the vast expanse of eucalypt savanna and acacia scrub that characterise subcoastal tropical Australia. Site data from Forty Mile Scrub was included in two (sub-groups 4b and 6c) out of 16 segments of the floristic continuum represented by the rainforest of inland Queensland between latitudes 17°00' to 23°26.5'S that were surveyed by Fensham (1995).

Mean annual rainfall at the nearest long-term weather station, Mount Surprise (50 km to the W), is 803 mm, where about 80% of the rain falls between December and March (105 years of record; Bureau of Meteorology 1988). Between 1983 and 1992 complete rainfall records are available for six years but were unavailable for 1983, 1984, 1989 and 1991 (Bureau of Meteorology unpublished data). 1986 was the only year with above-average rainfall and total annual rainfall was only 398 and 555 in 1990 and 1991 respectively. Mean daily maximum temperature is 35.4°C in November and mean daily minimum temperature is 9.5°C in July (Bureau of Meteorology 1988).

Physical setting

Incised water courses are absent throughout the dry rainforest and all quadrats surveyed in this study had slopes of less than 5%. The main massif of dry rainforest (Fig. 1) is restricted to deeply weathered basalt soils of the McBride province (Isbell et al. 1976). The O-horizon is less than 2 cm deep and the dark reddish brown (5YR 3/3) clay loam A-horizon extends beyond 50 cm on the basalt soils (Fensham et al. 1994). The northwesterly patch of dry rainforest occurs on soils derived from lateritic substrates.

Methods

The largest patch of dry rainforest at Forty Mile Scrub National Park is 2380 ha and was the site of the following quadrat-based study from which the structural description was developed. A large portion of the dry rainforest at Forty Mile Scrub is severely degraded by the proliferation of the exotic shrub lantana (*Lantana camara*) and the incursion of fire (Fensham et al. 1994). These phenomena are probably the result of structural damage (Fensham et al. 1994). This project seeks to describe dry rainforest in relatively natural condition so quadrats were restricted to those areas of the rainforest where there was little (< less than 5000 plants per ha) or no lantana (Fig. 1).

Sampling was conducted in October and November 1992, using fifty 10 × 10 m quadrats spaced every 100 m along seven transects (Fig. 1).

In each quadrat the following were recorded: a) the diameter at breast height of all native trees and shrubs greater than 3 m tall; b) the identity of all plant species, except herbaceous ephemerals and grasses which could not be consistently identified during the sampling period (taxonomic authorities follow Henderson 1994); c) an estimate of percentage canopy cover (as per Walker & Hopkins 1990) of trees greater than 4 m above ground; d) an estimate of the percentage cover of rock.

In a 1 m strip around the perimeter of each quadrat the following were recorded: e) the number and identity of all native shrubs and trees, greater than 50 cm tall and less than

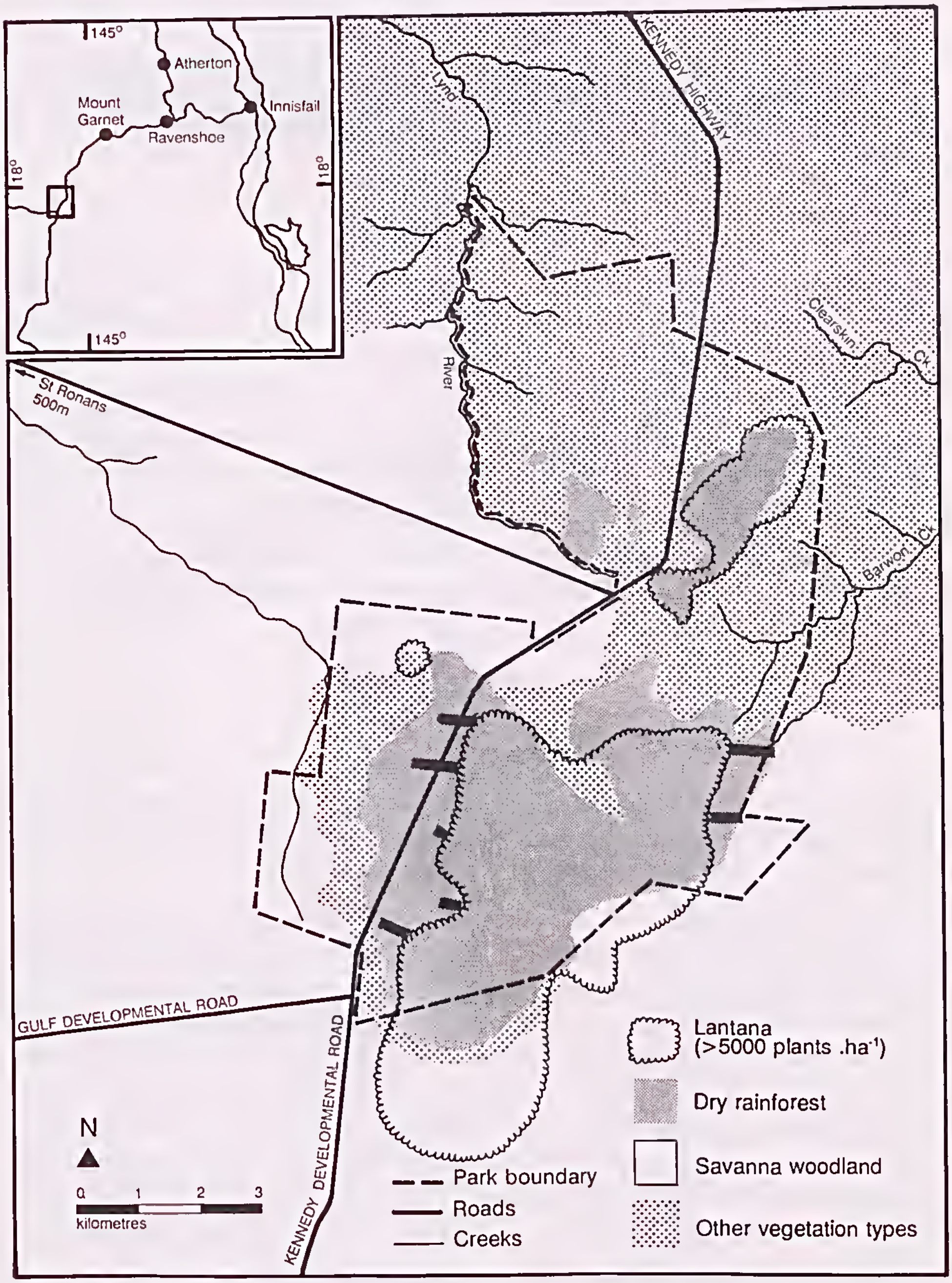


Fig. 1. Locality map showing vegetation types and position of transects as thick black lines.

3 m that have the potential to achieve greater than 2 m in height; and f) the number and identity of all native woody plants less than 50 cm tall.

A soil sample collected from between 2 and 10 cm depth from the centre of each quadrat was analysed for electrical conductivity using a TPS LC84 meter and pH using a TPS LC80 meter (TPS Pty Ltd, Brisbane). The distance of each plot to the edge of the rainforest was determined from aerial photography (1: 20 000).

Vascular plant species were also recorded during eight hours of foot traverse in the largest rainforest patch and two hours in the two next largest rainforest blocks (Fig. 1). Two hours of foot traverse in the large patch was conducted after considerable rain which had prompted growth and flowering of the ephemeral ground layer.

Analytical methods

All data were stored, manipulated and ordinated using the DECODA software (Minchin 1990). The non-metric multi-dimensional scaling technique (KYST) was performed in one dimension because of the monotony of substrate and vegetation, using default settings and presence–absence data.

Relationships between the ordination scores, the basal area of individual tree species and the measured environmental variables were tested using Spearman's rank correlation coefficients.

Stand structure histograms were prepared for the five most frequent tree species and for all species whose mature individuals are typically greater than 3 m tall.

Results

General description

The surface of the basaltic soils generally have low rock cover although slightly raised ridges occur throughout the dry rainforest with up to 90% rock cover (Table 1). Surface soils are neutral and pH varies between 6.0 and 7.5 (Table 1).

Existing checklists of plants for this area (Anon 1961; Kahn & Lawrie 1987) are out of date and difficult to reconcile with current names. An updated checklist is provided in Appendix 1; 151 native vascular plant species were recorded in the rainforest at Forty Mile Scrub National Park. Euphorbiaceae (12 species), Malvaceae (8 species) and Rubiaceae (8 species) are the largest families. Trees constitute 36% of the native taxa, 10% are small trees, 7% shrubs, 7% subshrubs, 11% vines, 25% herbs and 5% ferns (see Appendix 1 for lifeform definitions). Ninety-six percent of the native trees, shrubs and vines known from the scrub are known from within 1 km of the Queensland coast. In contrast, for the inland north Queensland dry rainforests as a whole, 87% of the species in those lifeform groups were not known from the Queensland coast (Fensham 1995).

The rainforest generally has greater than 50% canopy cover (Table 1). Table 2 shows the basal area, stem density and frequency of occurrence of the most common tree species

Table 1. Summary of environmental values in 50 dry rainforest 10 × 10 m quadrats at Forty Mile Scrub

	> 4 m canopy cover (%)	rock cover (%)	pH	conductivity (mS cm^{-2})	distance to savanna (km)	KYST1
Minimum value	20	0.0	6.0	0.01	0.0	0.00
Mean value	53	9.8	6.8	0.10	0.624	0.59
Maximum value	95	90.0	7.5	0.30	2.0	1.52

Table 2. Percentage frequency, basal area and number of stems for all plants sampled greater than 1.4 m high. Only species occurring in five or more quadrats are included

Species	**Sampled frequency (%)**	**Basal area (m^{2}ha^{-1}) (ha^{-1})**	**number of stems**
Acacia aulacocarpa	38	0.9723	38
Acronychia laevis	14	0.2866	38
Alectryon connatus	80	1.0335	162
Alphitonia excelsa	30	0.0906	6
Antidesma parvifolium	12	0.0328	6
Austromyrtus sp. (Forty Mile Scrub G.C. Stocker 1785)	62	1.1832	262
Breynia oblongifolia	68	0.0088	16
Briedelia leichhardtii	52	0.8681	54
Canthium sp. R.J. Fensham 632	46	0.0776	74
Canthium vacciniifolium	66	0.0349	38
Carissa ovata	88	0.0028	8
Citriobatus spinescens	64	0.1012	40
Cupaniopsis anacardioides	10	0.1855	6
Denhamia oleaster	56	0.5455	68
Diospyros humilis	80	0.6987	104
Drypetes deplanchei	36	2.3655	56
Ehretia membranifolia	22	0.3038	36
Erythroxylum australe	28	0.6385	26
Ficus platypoda	10	0.4560	8
Flueggea leucopyros	20	0.0303	8
Geijera salicifolia	72	0.7938	102
Notelaea microcarpa	78	3.5724	714
Ozothamnus cassinioides	60	0.1643	44
Pleiogynium timorense	14	0.4556	14
Psychotria daphnoides	26	0.0000	0
Rapanea variabilis	22	0.0203	40
Senna surratensis subsp. *surratensis*	10	0.0002	2
Siphonodon australis	18	0.6506	32
Strychnos psilosperma	52	3.4922	138
Turraea pubescens	34	0.0052	12
Total species		**21.1295**	**2236**

occurring in sizes greater than 1.4 m high. There was an average of 11,155 seedlings and saplings (< 3 m high) per ha. The most continuous canopy layer is 5–7 m high and *Notelaea microcarpa* is the most dominant species within this layer. Other common tree species in this layer are *Alectryon connatus, Austromyrtus* sp. (Forty Mile Scrub G.C. Stocker 1785), *Drypetes deplanchei, Geijera salicifolia* and *Strychnos psilosperma.* Dry rainforest emergents protrude from the closed canopy to a height of between 8 and 15 m and include the species *Ailanthus triphysa, Brachychiton australis, Pleiogynium timorense* and *Siphonodon australis.* Emergents of these relatively tall rainforest species > 20 cm dbh were recorded at a density of 26 trees per ha. Mature individuals of *Eucalyptus crebra, Eucalyptus erythrophloia* and *Eucalyptus tereticornis* to 20 m tall, species dominant in savanna vegetation surrounding the rainforest, are also emergent in some areas.

Diospyros humilis is common as a spreading small tree under the closed canopy of the forest, while *Carissa ovata* and *Canthium vaccinifolium* are spiny sclerophyllous shrubs in the understorey. The ephemeral ground layer has less than 5% cover following rain, with herbs and resurrection ferns in the family Sinopteridaceae (listed in Appendix 1) having sporadic distribution.

Two native species, *Margaritaria dubium-traceyi* and *Cyperus isabellinus,* were only recorded in the northwestern rainforest patch on lateritic substrate and not from the other surveyed patches on basalt.

Eight exotic species were recorded as naturalised in the forest. The shrub *Lantana camara* has infested a large proportion of the rainforest (Fensham et al. 1994) and the annual daisy *Ageratum conyzoides* is frequent in some areas following rain. The vine *Solanum seaforthianum* is common in some areas, while the other exotic species have only limited distribution in the rainforest.

Ordination

The KYST ordination axis was negatively correlated with rock cover and pH (Table 3). Thus variations in edaphic conditions may have some control over the relatively subtle vegetation patterns within the dry rainforest. However, the basal areas of only two of 13 common tree species had weak ($0.01 < P < 0.05$) correlations with rockiness (Table 3) and the abundance of none of nine small trees and shrubs showed any significant relationship with rockiness (Table 4; $P > 0.05$). The basal areas of four common tree species (Table 3) and the abundances of three small tree and shrub species (Table 3) were significantly ($P < 0.05$) correlated with the relatively minor variations in surface soil pH. The basal areas of seven of the common tree species and four of the common small tree and shrub species were not correlated to any measured environmental factor (Table 3 and 4).

The KYST ordination axis was also negatively correlated with the distance from the rainforest boundary although the basal area of no individual tree species was correlated with this factor. A significant negative correlation between the abundance of the small tree species *Rapanea variabilis* with the distance from the edge of the rainforest (Table 4) is indicative of the ecotonal habitat of this species.

Size class

The size class histogram for all tree species provides an indication of the overall structure of the forest (Fig. 2). The histogram reveals declining densities of trees as size classes increase. However, this histogram sheds little light on regeneration patterns in this particular dry rainforest because the majority of individuals in the small size classes are individuals of two tree species *Diospyros humilis* and *Turraea pubescens* that are only rarely represented in larger size classes. *Alectryon connatus* has the highest proportion (45.2%) of seedlings (< 50 cm high) relative to the other common species (Fig. 2). Low densities of small size classes are particularly marked for *Austromyrtus* sp. (Forty Mile Scrub G.C. Stocker 1785), *Notelaea microcarpa* and *Strychnos psilosperma* (Fig. 2). These species have less than 13% seedlings and less than 26% seedlings and saplings (> 50 cm high; < 300 cm high) in combination.

Table 3. Spearman's rank correlation coefficients between basal area of tree species, environmental variables and ordination scores. Only species occurring in ten or more quadrats are included

	> 4 m canopy cover	rock cover	pH	conductivity	distance to savanna	KYST1
Acacia aulacocarpa	NS	-0.34*	-0.43**	NS	NS	NS
Austromyrtus sp. (Forty Mile Scrub G.C. Stocker 1785)	NS	NS	0.34*	0.30*	NS	NS
Canthium sp. (R.J. Fensham 632)	NS	NS	0.42**	NS	NS	-0.47***
Drypetes deplanchei	0.50***	NS	NS	NS	NS	NS
Strychnos psilosperma	NS	0.33*	NS	0.33*	NS	NS
Turraea pubescens	NS	NS	0.35*	NS	NS	-0.32*
KYST1	NS	-0.29*	-0.36**	NS	-0.29*	

Tree species with no significant relations to measured factors (P > 0.05): *Alectryon connatus, Alphitonia excelsa, Denhamia oleaster, Diospyros humilis, Ehretia membranifolia, Geijera salicifolia, Notelaea microcarpa*

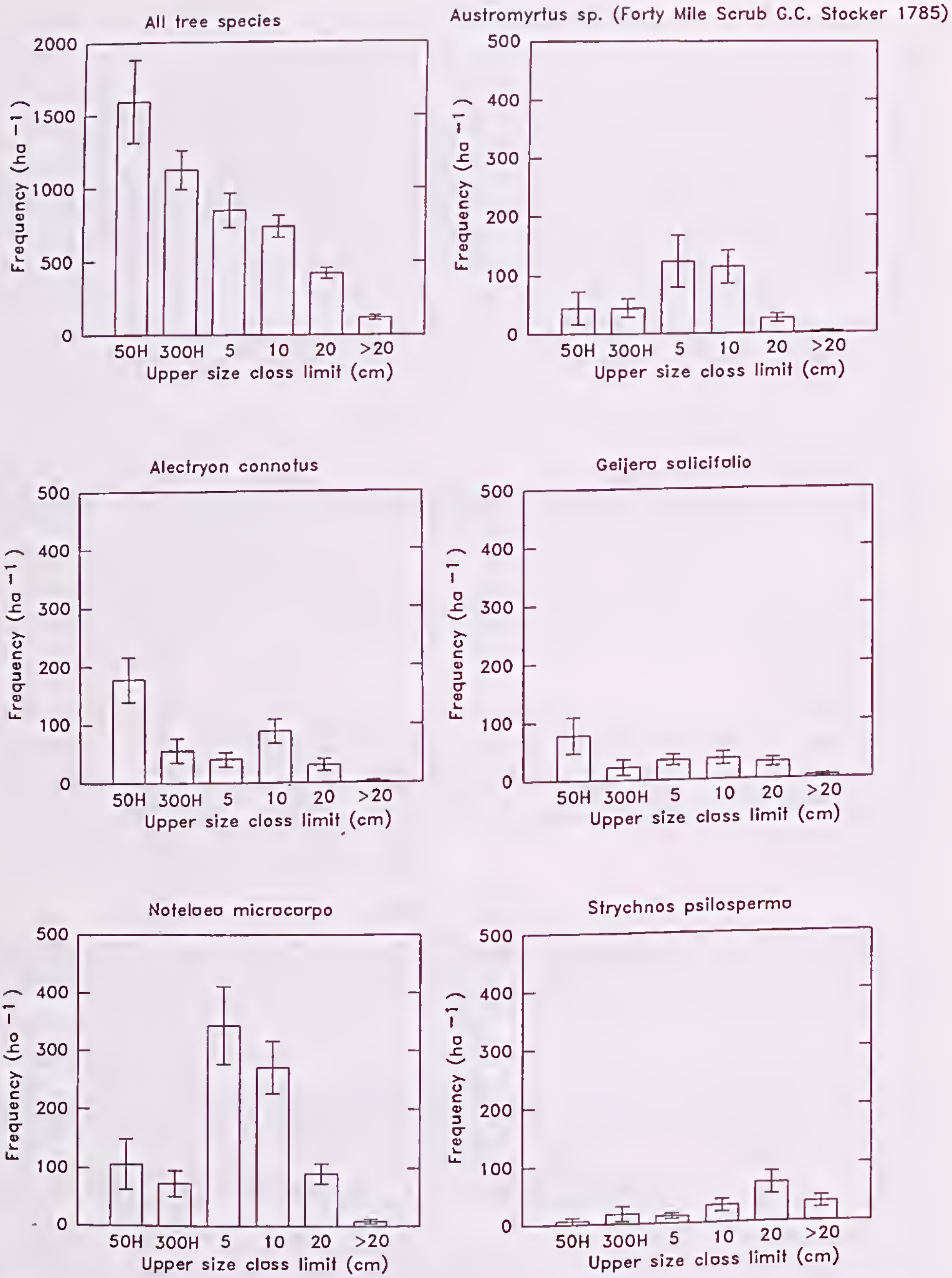
*** P < 0.001; ** P < 0.01; * P < 0.05; NS P > 0.05

Table 4. Spearman's rank correlation coefficients between densities of small tree and shrub species, environmental variables and ordination scores. Only species occurring in ten or more quadrats are included

	> 4 m canopy cover	rock cover	pH	conductivity	distance to savanna	KYST1
Breynia oblongifolia	NS	NS	0.32*	NS	NS	NS
Briedelia leichhardtii	NS	NS	0.32*	NS	NS	NS
Canthium vacciniifolium	NS	NS	NS	NS	NS	0.40**
Ozothamnus cassinioides	NS	NS	-0.36*	NS	NS	NS
Rapanea variabilis	NS	NS	NS	NS	-0.36*	NS

Small tree and shrub species with no significant relations to measured factors (P > 0.05): *Carissa ovata, Citriobatus spinescens, Flueggea leucopyros, Psychotria daphnoides*

*** P < 0.001; ** P < 0.01; * P < 0.05; NS P > 0.05


All tree species

Austromyrtus sp. (Forty Mile Scrub G.C. Stocker 1785)

Alectryon connatus

Geijera salicifolia

Notelaea microcarpa

Strychnos psilosperma

Fig. 2. Frequency/size class histograms for all tree species (mature plants > 5m high) and the five most abundant tree taxa. H = height and other values represent diameter at breast height.

Discussion

There are studies that present stand structure from analagous closed tropical forests elsewhere in the dry tropics (e.g. Dittus 1977; Murphy and Lugo 1986). However, most studies do not include data on seedling and sapling densities or cannot be related to unit area. I was unable to locate any studies that provide complete stand structure for individual species in dry rainforest. Bowman and Fensham (1991) present total densities (all woody plants less than 1.5 m high) between 45–50,000 per ha for monsoon rainforest at Weipa in far north Queensland. The numbers for woody plants < 3 m high presented here for Forty Mile Scrub are between 4 and 5 times lower than in analagous vegetation at Weipa. Russell–Smith et al. (1993) record mean seedling densities (< 20 cm high) of between 2200 and 18,500 per ha in *Allosyncarpia ternata* dominated rainforest types on the Arnhem Land Plateau in the Northern Territory. These values are between 1.4 and 11.5 times higher than for seedlings (< 50 cm high) densities in Forty Mile Scrub. Weipa and the Arnhem Land Plateau study area of Russell–Smith et al. (1993) have strongly seasonal mean annual rainfalls of 2250 mm, and 1200–1550 mm pa respectively. These values are, for Weipa 2.8 times higher, and for the Arnhem Land Plateau between 1.5 and 1.9 higher than Forty Mile Scrub. These trends may indicate that seedling densities increase with mean soil moisture values in rainforest vegetation on seasonally dry substrates.

Sukumar et al. (1992) measured about 5000 stems per ha for 1–2.5 cm dbh stems in deciduous forest in southern India. Although no data are provided, they note that many species including common dominants are represented by a general lack of the smaller size classes. The decade preceding this study was marked by below average rainfall (see above) and it appears that the regeneration of many species in dry rainforest may be a phasic event. Such an event may coincide with a series of high rainfall years perhaps only once every few decades. However, the details of seedling establishment and recruitment and the rates of such processes in dry rainforest will remain a mystery until further studies are complete.

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Appendix 1

Vascular plant species list for dry rainforest at Forty Mile Scrub. Species found only at disturbed edges of rainforest (i.e. along the highway) or confined to the dry rainforest ecotone are not included. Undescribed species where the bracketed reference is includes a location (e.g. *Sida* sp. Greenvale R.J. Fensham 1150) are recognised by BRI, other undescribed species identified simply by a collecting number (specimens are held at BRI) are awaiting confirmation of their status as distinct taxa).

f fern
h herb (non-woody plant)
v plants with long stems without intrinsic means of support
ss sub-shrub (mature plants marginally woody; less than 1m tall)
s shrub (woody; mature plants less than 3 m tall)
st small tree (woody; mature plants 3–5m tall)
t tree (woody; mature plants > 5m tall)
* exotic

PTERIDIOPHYTA

Ophioglossaceae
- *Ophioglossum reticulatum* f

Polypodiaceae
- *Platycerium veitchii* f
- *Pyrrosia rupestris* f

Sinopteridaceae
- *Cheilanthes nudiuscula* f
- *Cheilanthes distans* f
- *Cheilanthes sieberi* f
- *Doryopteris concolor* f

GYMNOSPERMAE

Cupressaceae
- *Callitris intratropica* t

ANGIOSPERMAE

Acanthaceae
- *Hypoestes floribunda* h
- *Pseuderanthemum variabile* h
- *Rostellularia adscendens* h

Amaranthaceae
- *Deeringia amaranthoides* s

Anacardiaceae
- *Euroschinus falcata* t
- *Pleiogynum timorense* t

Annonaceae
- *Melodorum leichhardtii* t

Apiaceae
- *Hydrocotyle acutiloba* h

Apocynaceae
- *Alyxia ruscifolia* s
- *Carissa ovata* s
- *Parsonsia lanceolata* v
- *Parsonsia plaesiophylla* v

Araliaceae
- *Polyscias elegans* t

Asclepiadaceae
- *Cryptostegia grandiflorum** v
- *Cynanchum bowmanii* v
- *Gymnema pleiadenium* v
- *Sarcostemma viminale* subsp. *brunonianum* v
- *Secamone elliptica* v

Asteraceae
- *Ageratum conyzoides** h
- *Conyza bonariensis** h
- *Lagenifera* sp. (R.J. Fensham 1113) h
- *Olearia canescens* s
- *Ozothamnus cassinioides* st
- *Parthenium hysterophorus** h
- *Vernonia cinerea* h

Bignoniaceae
- *Pandorea pandorana* v

Boraginaceae
- *Cordia dichotoma* st
- *Ehretia membranifolia* t
- *Trichodesma zeylanica* h

Brassicaceae
- *Cardamine hirsuta* h

Caesalpiniaceae
- *Senna barclayana* s
- *Senna surratensis* subsp. *retusa* s
- *Senna surratensis* subsp. *surratensis* s

Capparaceae
- *Capparis arborea* t

Celastraceae
- *Cassine melanocarpa* t
- *Denhamia oleaster* t
- *Denhamia pittosporoides* t
- *Maytenus cunninghamii* t
- *Maytenus disperma* t
- *Siphonodon australis* t

Commelinaceae
- *Commelina cyanea* h

Convolvulaceae
Ipomoea saintronanensis v

Cyperaceae
Cyperus dietrichiae h
Cyperus gracilis h
Cyperus isabellinus h
Scleria macaviensis h

Ebenaceae
Diospyros humilis t

Erythroxylaceae
Erythroxylum australe st

Euphorbiaceae
Antidesma parvifolium st
Breynia oblongifolia st
Briedelia leichhardtii st
Claoxylon tenerifolium t
Croton arnhemicus t
Drypetes deplanchei t
Fleuggea leucopyrus st
Fluggea virosa subsp. *melanthesioides* st
Mallotus philippensis t
Margaritaria dubium-traceyi t
*Phyllanthus debilis**ss
Phyllanthus similis s
Phyllanthus novae-hollandiae t

Fabaceae
Crotalaria verrucosa h

Hernandiaceae
Gyrocarpus americanus t

Lamiaceae
Plectranthus parviflorus h

Lauraceae
Cassytha pubescens v

Liliaceae
Dianella caerulea h

Loganiaceae
Strychnos axillaris t

Loranthaceae
Amyema congener h
Dendropthoe homoplastica h

Malphigiaceae
Rhyssopterys timorensis v

Malvaceae
Abutilon oxycarpum ss
Abutilon indicum st
Hibiscus sturtii ss
Hibiscus vitifolius ss
Malvastrum americanum ss
Melhania brachycarpa ss
Sida sp. (Greenvale R.J. Fensham 1150) ss
Sida subspicata ss

Meliaceae
Melia azedarach t
Turraea pubescens t

Menisperiaceae
Stephania japonica v

Mimosaceae
Acacia aulacocarpa t

Moraceae
Ficus opposita t
Ficus platypoda t

Myrsinaceae
Rapanea variabilis st

Myrtaceae
Austromyrtus sp.
(Forty Mile Scrub G.C. Stocker 1785) t
Eucalyptus crebra t
Eucalyptus erythrophloia t
Eucalyptus tereticornis t

Oleaceae
Notelaea microcarpa t
Olea paniculata t

Orchidaceae
Cymbidium canaliculatum h
Dendrobium bowmanii h
Dendrobium monophyllum h
Dendrobium linguiforme h
Saccolabiopsis armitii h
Sarcochilus minutiflos h

Oxalidaceae
Oxalis perrenans h

Passifloraceae
*Passiflora foetida** v

Piperaceae
Peperomia blanda var. *floribunda* h

Pittosporaceae
Citriobatus spinescens st
Pittosporum rhombifolium t

Plumbaginaceae
Plumbago zeylanica h

Poaceae
Ancistrachne uncinulata h
Aristida gracilipes h
Arthragrostis deschampsioides h
Digitaria minima h
Lepturus sp.
(Chillagoe M. Godwin C2576) h
Oplismenus aemulus h
Panicum trichoides h

Ranunculaceae
Clematis pickeringii v

Rhamnaceae
Alphitonia excelsa t

Rubiaceae
Canthium odoratum t
Canthium sp. (R.J. Fensham 632) t
Canthium vacciniifolium s
Larsenaikia ochreata t
Mitracarpus hirtus h
Pavetta australiensis st
Psychotria daphnoides var. *angustifolia* st
Spermacoce sp. (R.J. Fensham 1097) h

Rutaceae
Acronychia laevis t
Geijera salicifolia t
Zanthoxylum brachyacanthum t

Santalaceae
  Exocarpos latifolius t
  Santalum lanceolata t

Sapindaceae
  Alectyron connatus t
  Cupaniopsis anacardioides t
  Dodonaea lanceolata st

Sapotaceae
  Planchonella cotinifolia t

Simaroubaceae
  Ailanthus triphysa t

Smilacaceae
  Eustrephus latifolius v

Solanaceae
  Solanum cookii ss
  *Solanum seaforthianum** v
  Solanum stelligerum ss

Sterculiaceae
  Brachychiton australis t
  Brachychiton chillagoensis t
  Waltheria indica ss

Tiliaceae
  Grewia papuana st
  Grewia retusifolia s

Ulmaceae
  Trema tomentosa st

Urticaceae
  Laportea interrupta h

Verbenaceae
  Clerodendrum tomentosum t
  Clerodendrum floribundum t
  *Lantana camara** s
  Premna acuminata t
  Vitex melicope t

Violaceae
  Hybanthus stellarioides h

Vitaceae
  Cayratia trifolia v
  Cissus oblonga v
  Cissus opaca v
  Cissus reniformis v

Semi-evergreen vine thicket vegetation at Derra Derra Ridge, Bingara, New South Wales

J.S. Benson, R. Dick and A. Zubovic

Benson, J.S.[1], Dick, R.[2] and Zubovic, A.[2] ([1] National Herbarium of New South Wales, Royal Botanic Gardens, Sydney, NSW, Australia 2000, [2] Land Assessment Unit, National Parks and Wildlife Service PO Box 1967 Hurstville, NSW, Australia 2220) 1996. Semi-evergreen vine thicket vegetation at Derra Derra Ridge, Bingara, New South Wales Cunninghamia *4(3): 497–510.* Semi-evergreen vine thicket (SEVT) in New South Wales is mainly restricted to a few basalt hills on the North Western Slopes, although it is more common in Queensland (other dry rainforests are present in north-western Australia). SEVT has been largely cleared in both States and is a threatened vegetation type. Derra Derra Ridge (lat 29°52' long 150°27') contains the largest area of SEVT in NSW. Eight plant communities are mapped for the area. The vine thicket is dominated by *Notelaea microcarpa* var. *microcarpa*, *Cassine australis* var *angustifolia* and *Geijera parvifolia*, with *Eucalyptus melanophloia* and *Callitris glaucophylla* as emergent trees. Small patches of brigalow, *Acacia harpophylla* and hummock grass, *Triodia scariosa* subsp. *scariosa* add to the biogeographic significance of the area. Ninety vascular plant species were recorded. A nationally listed rare legume, *Isotropis foliosa*, is present in low numbers. Comparisons are made with another vine thicket, Planchonella Hill, further north. It is recommended that at least the Crown land component of Derra Derra Ridge (1458 ha) should be fenced off from stock, destocked, and be dedicated and managed as a nature reserve.

Introduction

Location, geology, climate and land use

Derra Derra Ridge, latitude 29°52' longitude 150°27', is located in the Shire of Bingara, 12 km west of Bingara, 12 km south of the junction of the Gwydir and Horton rivers, and 80 km north-east of Narrabri, on the North Western Slopes of NSW (Fig. 1).

Derra Derra Ridge rises to a height of 690 m from 400 m at its base. It is 12 km west of the Peel Fault that separates the New England Block from the Tamworth Fold Belt (Rob 1974). Most of the Ridge is composed of a residual capping of Tertiary basalt derived from lava flows of the Nandewar volcanism at Mount Kaputar 18–17 million years ago (Wellman & McDougall 1974). The basalt is underlain by mudstone of the Luton Formation of the lower Carboniferous (NSW Department of Mines 1971). This mudstone outcrops on some of the slopes on the Derra Derra Ridge.

The average annual rainfall of nearby Bingara is 745 mm. This peaks over summer with an average of 92 mm in January, while winter is drier with an average of 45 mm in August. The average summer maximum temperates are 33° with a minimum of 18°. The average winter maximum temperatures are 19° and with a minimum of 3° (Bureau of Meteorology 1988).

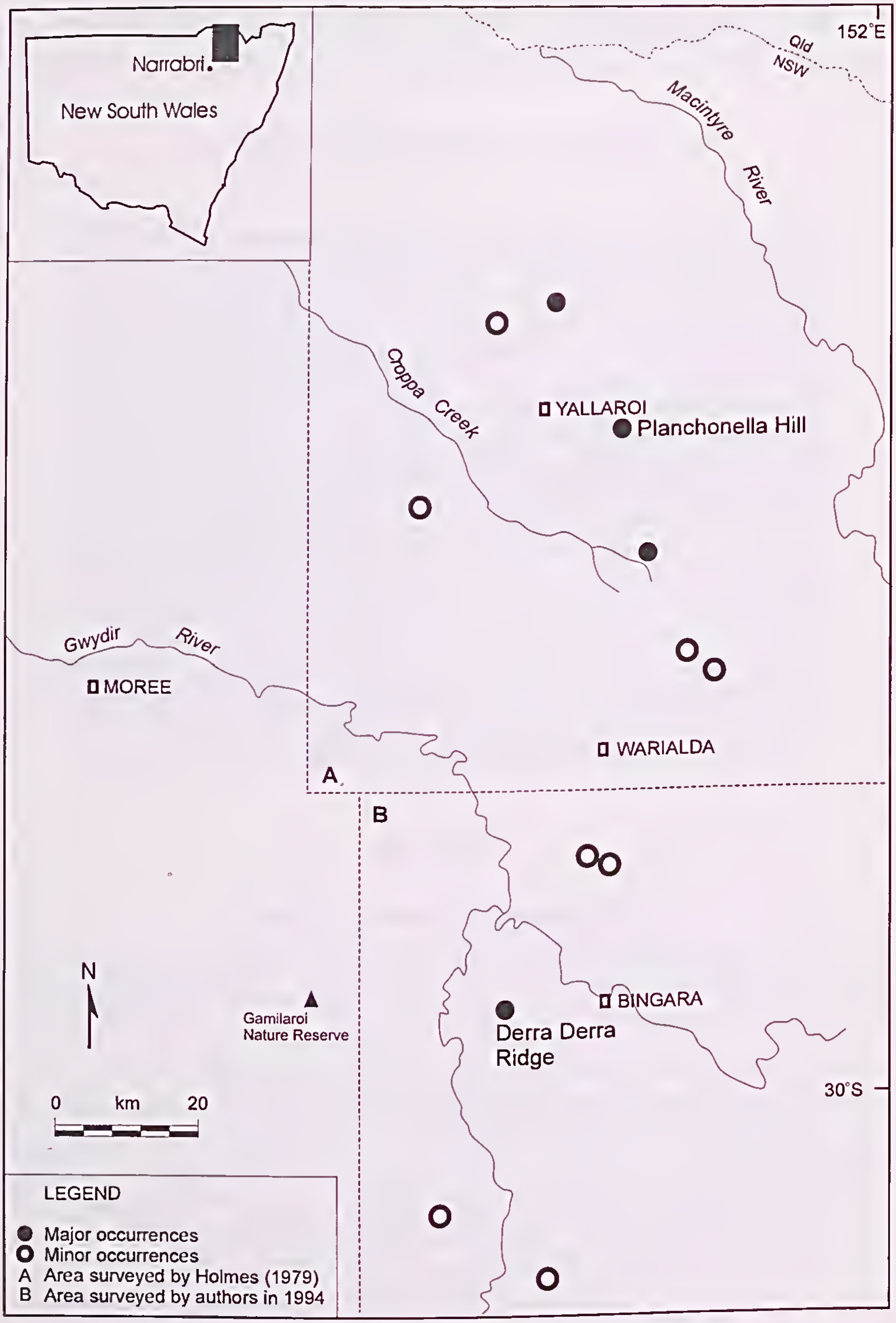

Fig 1. Location of Derra Derra and other occurrences of semi-evergreen vine thicket on the North Western Slopes of New South Wales.

Most of the undulating landscape in the Bingara region has been cleared for agriculture, but natural vegetation remains on steeper country, some of which is State Forest. The remnant vegetation on Derra Derra Ridge occupies 4120 ha (Fig. 2), of which 1500 ha is Crown land held under an annual licence for grazing and the remainder is private land. Wheat and other grains are grown on the surrounding rich colluvial and alluvial soils.

Semi-evergreen vine thickets

The term 'semi-evergreen vine thicket' (SEVT) is defined in Webb's (1978) physiognomic-structural classification of Australian rainforests. It is a type of 'dry' rainforest that has adapted to seasonal variability (Gillison 1987). 'Dry' rainforests include: northern Australian monsoon forests (Russell–Smith 1991), patches of dry rainforest in the Kimberley of Western Australia (Mckenzie et al. 1991), the softwood scrubs of inland Queensland and northern NSW (Forster et al. 1991), hoop pine scrubs of Queensland and New Guinea, and the dry rainforests of the north coast gorges (King 1980, National Parks and Wildlife Service 1985) and the Hunter Valley (Turner & Vernon 1994) of NSW. Because of some shared structural and floristic similarities to littoral dune rainforest, it is conjectured these inland 'dry' rainforests may have coastal origins (Gillison 1987). In a study of dry rainforests of inland north Queensland, Fensham (1995) found that 87% of trees, shrubs and vines also occurred on the north Queensland coast.

The vine thickets on the North Western Slopes, including Derra Derra, fit with the Webb (1978) structural category of semi-evergreen vine forest (SEVT). The trees and shrubs are

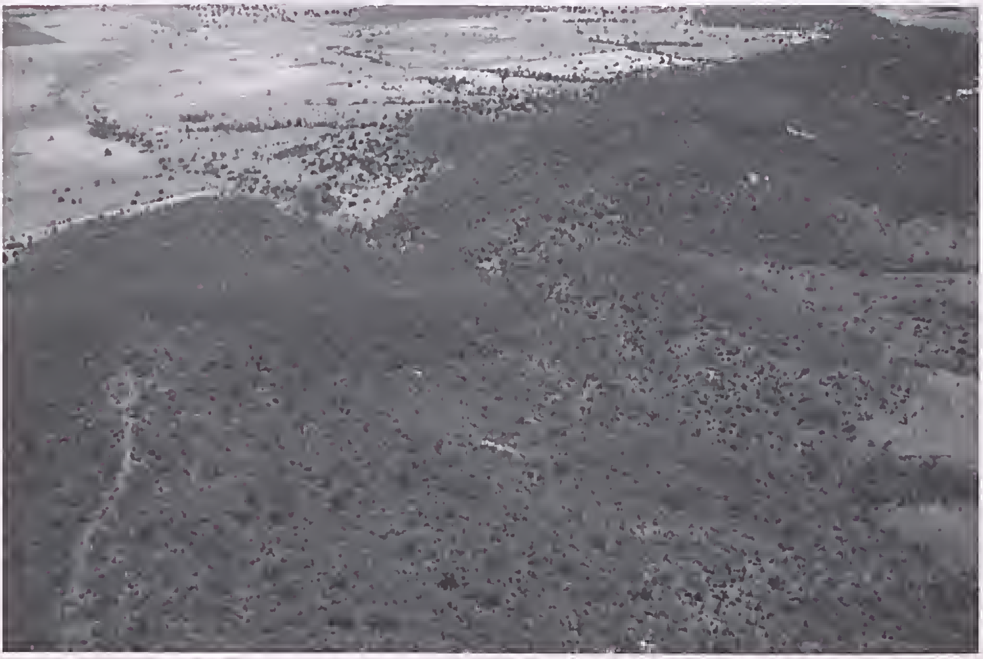

Fig. 2. Oblique aerial photograph of Derra Derra Ridge showing it is a native vegetation remnant surrounded by cleared crop and grazing land. (Photo: J. Benson)

less than 10 m in height, most species have small leaves (microphyll) and facultatively deciduous tree species are usually present. There are fewer deciduous species in the thickets in NSW than those in Queensland (Forster et al. 1991). Vine thickets often contain emergent trees that may be typical of surrounding woodlands. Floyd (1990) placed NSW vine thickets under suballiance No. 32 *Notelaea microcarpa – Ehretia membranifolia – Geijera parviflora* in his floristic classification of rainforest in NSW.

Stands of SEVT on the North Western Slopes of NSW are shown on Fig. 1. Those north of Warialda were identified by Holmes (1979) during a survey of remnant vegetation on Tertiary basalt. Several of these remnants were cleared in the early 1980s. The largest and best preserved SEVT identified by Holmes (1979), a 450 ha remnant at Planchonella Hill near Yetman, was subsequently documented by Pulsford (1983) and recently purchased by the NSW National Parks and Wildlife Service for management as a nature reserve. Hull (1992) prepared a plant species list of the SEVT at Derra Derra and first noted the botanical significance of the area. The SEVT on Derra Derra Ridge is at, or near, the southern limit for SEVT in Australia, although Floyd (1990) includes the dry rainforest of the Hunter Valley, 150 km to the south-east of Derra Derra, under the same suballiance in his floristic classification. While there may be similarities with upper Hunter Valley dry rainforest, the lower Hunter dry rainforest, documented by Turner and Vernon (1994), is structurally and floristically different from the SEVT on the north-western slopes.

Methods

The survey involved aerial and ground survey of the SEVT at Derra Derra Ridge, as well as a regional assessment to identify other SEVT occurring in the Bingara region, which lies south of the region surveyed by Holmes (1979).

Aerial photographic interpretation (API) of 1: 50 000 black-and-white aerial photos taken in 1985 formed the basis for discerning the main structural variation of the vegetation on Derra Derra Ridge. The API was refined during and after the field survey which took place over two days in December 1994. Seven 20 × 20 m plots were sampled, covering the major vegetation types identified from the API. At each plot, vascular plant species were assigned a cover rating based on a modified Braun–Blanquet six point scale (Benson 1994). Physiographic attributes, slope, aspect, altitude, soil texture and substrate were also recorded (Table 1). The plot data is stored on a relational database at the National Herbarium of New South Wales. A species list was developed from these sites and other records. Data analysis was not undertaken due to the small size of the data set.

Native vegetation remnants on Tertiary basalt within 20 km of Bingara were mapped by overlaying native vegetation discerned from recent LANDSAT TM images on 1: 250 000 geology maps covering the region (Fig. 1). These were surveyed by air using a light aircraft to determine whether they contained SEVT.

Table 1. Location (Terry Hie Hie 1: 50 000 topographic map), geology, soils, landform, altitude, slope and aspect for sample sites at Derra Derra Ridge

Site	AMG Grid Ref.	Geol.	Soil	Landform	Alt (m)	Slope (°)	Aspect (°)
SEVT001	253800 6692200	Basalt	Brown loam	Upper slope	640	7	330
SEVT002	253000 6694200	Basalt	Brown loam	Lower slope	425	40	340
SEVT003	253600 6694400	Basalt	Brown loam	Lower slope	450	12	200
SEVT004	253600 6694600	M'stone	Brown clay	Upper slope	490	22	270
SEVT005	254200 6693400	Basalt	Brown loam	Ridge	610	0	0
SEVT006	253300 6692600	Basalt	Brown loam	Mid-slope	580	25	270
SEVT007	253200 6691500	Basalt	Brown loam	Mid-slope	540	5	120

Results

The aerial survey identified four small stands (< 20 ha) of SEVT additional to that occurring at Derra Derra Ridge. Derra Derra Ridge was confirmed as the largest stand of SEVT in the region.

Plant communities

Eight vegetation communities are mapped for Derra Derra Ridge (Fig. 3) based on varying structure (Walker & Hopkins 1990) and floristics. The SEVT, community 2 at Derra Derra Ridge occupies 1350 ha of the 4120 ha remnant. Most of the SEVT occupies the central section of the remnant on the basaltic upper slopes and ridges (Figs 3 and 4). Emergent *Eucalyptus albens* and *Callitris glaucophylla* are common here. About 990 ha of the SEVT occurs on Crown land and the remainder on private land. Vine thicket is less common on the lower slopes where a mid-high open woodland of *Eucalyptus albens* and *Eucalyptus melanophloia* (community 5) is prevalent. Some of the highest ridges support a mid-high open woodland composed of *Eucalyptus albens, Eucalyptus dealbata* and *Callitis glaucophylla* (community 1). Isolated stands of *Eucalyptus melanophloia* with *Callitris glaucophylla*, containing a dry open understorey (community 6), are present on stony rises on the lower northern slopes.

Open forest dominated by *Angophora floribunda* (community 3) occurs on the southern mid-slopes, while dense stands of *Melaleuca bracteata* (community 7) line water courses in the area.

A reference point on Fig. 3 coinciding with site 7 indicates the location of a small patch of dense forest of brigalow, *Acacia harpophylla*, (community 4). It occurs on the southern side of the main east–west ridge. A small patch of hummock grassland dominated by porcupine grass, *Triodia scariosa* subsp. *scariosa* (community 8) occurs on a north-western aspect on the northern side of the main east–west ridge, coinciding with site 6.

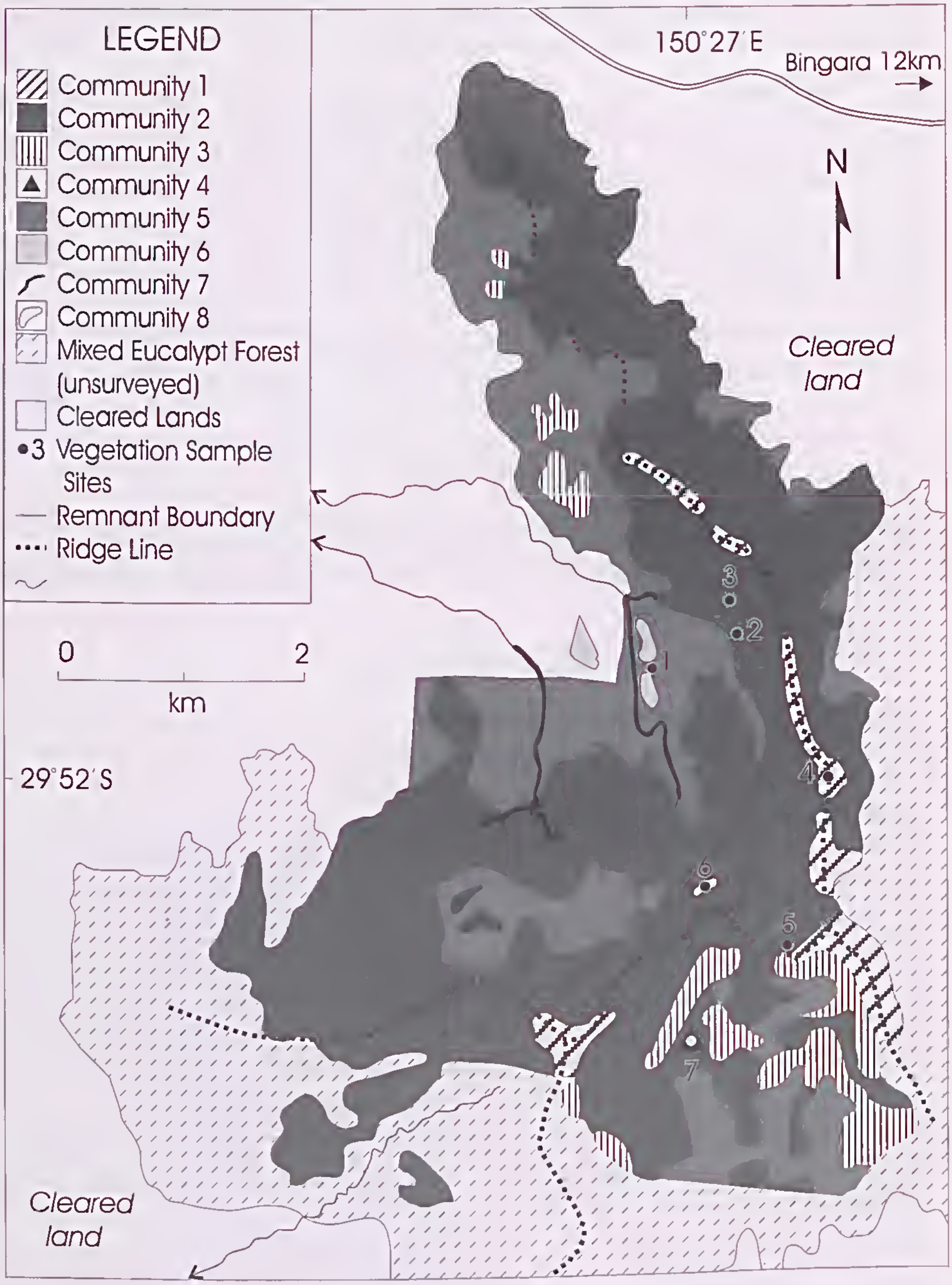

Fig. 3. Vegetation communities at Derra Derra Ridge. **Communities: 1.** Mid-high open woodland on higher slopes dominated by *Eucalyptus albens – E. melanophloia – Callitris glaucophylla*. **2.** Semi-evergreen vine thicket on mid to high slopes with emergent isolated trees of *Eucalyptus albens* and *E. melanophloia*. **3.** Mid-high open forest on southern aspects on mid-high slopes dominated by *Angophora floribunda*. **4.** Closed forest on east-facing terrace dominated by *Acacia harpophylla*. **5.** Mid-high open woodland on lower slopes dominated by *Eucalyptus albens* and *E. melanophloia*. **6.** Mid-high open woodland on stony lower ridges dominated by *Eucalyptus melanophloia* and *Callitris glaucophylla* with a dry open understorey. **7.** Mid-high closed forest along major drainage lines dominated by *Melaleuca bracteata*. **8.** Open hummock grassland on a rocky north-west facing slope dominated by *Triodia scariosa* subsp. *scariosa*.

The API and ground survey showed that the open woodland on the central section of Crown land has been thinned in the past. The tree cover is sparser there than adjacent areas. Most of the ridge contained a sparse ground layer. This was probably due to grazing by sheep combined with the effects of a prolonged drought.

Floristics

A total of 90 species (88 native and two exotic) have been recorded from all vegetation types on Derra Derra Ridge compared to 68 species (66 native and two exotic) for the Planchonella Hill remnant, 100 km to the north (Table 2). Many more species, particularly grasses and forbs, would be recorded from both locations with further survey over a range of seasons.

Commonly recorded plant species in the SEVT mapped as community 2 on Fig. 3 at Derra Derra were: emergent trees: *Eucalyptus melanophloia, Eucalyptus albens, Callitris glaucophylla*; trees and shrubs: *Canthium oleifolium, Cassine australis* var. *angustifolia, Alectryon subdentatus, Alstonia constricta, Geijera parviflora,* and *Notelaea microcarpa* var. *microcarpa*; understorey shrubs: *Beyeria viscosa, Dodonaea viscosa* var *angustifolia, Carissa ovata, Indigophora brevidens, Spartothamnella juncea, Pimelea neo-anglica* and *Phyllanthus subcrenulatus*; ground cover: the tall grasses *Aristida ramosa* and *Thellungia advena* were dominant in some parts, elsewhere the ground was largely bare due to drought. *Boerhavia dominii* and *Dichondra repens* were the most common forbs, along with the ground fern *Cheilanthes sieberi* subsp. *sieberi*. Climbers *Parsonsia eucalyptophylla* and *Pandorea pandorana* were found on shrubs and trees.

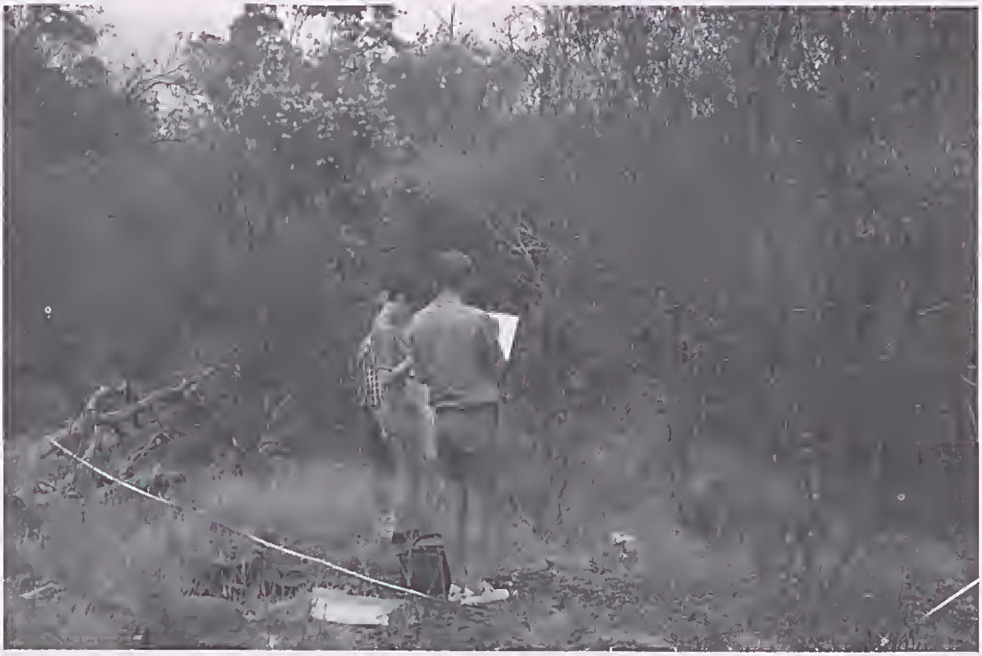

Fig. 4. Community 2 is composed of semi-evergreen vine thicket with emergent *Callitris glaucophylla, Eucalyptus albens* and *Eucalyptus melanophloia*. (Photo: R. Dick)

Common species in other communities on the Derra Derra Ridge included *Eucalyptus albens, Eucalyptus dealbata, Olearia elliptica, Gahnia aspera, Desmodium brachypodium, Solanum parvifolium, Cryptandra longistaminea, Correa glabra, Acacia cheelii* and *Poa sieberiana* var. *hirtelli*.

One nationally listed rare species was recorded. The legume, *Isotropis foliosa* described by Crisp (1987), was recorded in site 6 situated in community 8 composed of hummock grassland. It is coded 3KC- on the national rare or threatened Australian plant list (Briggs & Leigh 1996), a code that indicates it is of poorly known status, has a distribution of over 100 km, and is known from at least one conservation reserve. Only nine collections of this species are held in the National Herbarium of New South Wales, and seven of these are before 1980. One of the original collections was made by J.L. Boorman from Bingara in 1907. *Isotropis foliosa* is endangered in Queensland with only two population known from the Moreton District, both with less than 50 individuals (Crisp 1987, J. Briggs pers. comm.). The species was not recorded in any of the 232 plots in a survey of vine forests in Queensland (Forster et al. 1991), nor was it recorded by Sheringham and Westaway (1995) as occurring in the north-eastern part of NSW. However, *Isotropis foliosa* is known to be locally abundant at least one location in the upper Hunter Valley (J. Hoskings pers. comm.). It would appear to be an under-collected species, mainly present in agricultural regions but is not known to be protected in any conservation reserve. Several of the herbarium records have notes stating that the species may be poisonous to stock. Given the above, the exact status of *Isotropis foliosa* requires further examination.

A number of species recorded at Derra Derra are outside their areas of main distribution. The small stand of Brigalow, *Acacia harpophylla*, on the southern side of the ridge, represents an eastern limit for this species in NSW. The small patch of semi-arid hummock grass *Triodia scariosa* subsp. *scariosa* is of biogeographical interest as it grows only on one exposed north-west slope, surrounded by vine thicket. Whitewood, *Atalaya hemiglauca*, is near its eastern limit. *Acacia salicina* is widespread on the North Western Slopes and inland flood plains of NSW and Queensland but is most common on floodplains. Only two of the 16 records of this species in the National Herbarium of New South Wales record it as growing on ridges.

Prickly pear, *Opuntia stricta* subsp. *stricta*, was recorded in six of the seven plots at Derra Derra and was the most common introduced plant species in the area. Exotic herbaceous species may be common but were not present due to the drought.

Discussion

Edaphic factors appear to be important in determining the presence of SEVT. All occurrences of SEVT in NSW occur on deep, loamy, high nutrient soils derived from basalt. McKenzie et al. (1991) reveal that climate, moisture availability, nutrients and proximity to other patches explained the presence of and variation in dry rainforest composition in the Kimberley. Kelly et al. (1988) quoted in Farnsworth (1993) implicate soil moisture availability, calcium concentration and nutrient availability as key factors in the sustenance of semi-evergreen communities in the Carribbean. Similar factors may explain the restriction of SEVT to basalt on the North Western Slopes of NSW. In addition to the availability of nutrients, the fine-grained soil would retain moisture and enhance seedling establishment of mesic species. At Derra Derra Ridge site 4 was located on mudstone and the vegetation there was more open with fewer rainforest species, and dominated by shrubs such as *Correa glabra*.

The southern occurrences of SEVT in NSW differ in their floristic assemblage from the softwood scrubs in Queensland (Forster et al. 1991, Benson 1993) and species such as the bottle tree, *Brachychiton rupestris*, are absent. In Queensland, both brigalow, *Acacia harpophylla*, and ooline, *Cadellia pentastylis*, often co-exist with vine thicket species (Johnson 1964). A small patch of *Acacia harpophylla* is present at Derra Derra and at Planchonella Hill (Pulsford 1983), but it is not a dominant plant at any of the SEVT sites in NSW. It was once widespread on the gilgai soils on the plains north from Narrabri to the west of Derra Derra but has been extensively cleared (Pulsford 1984). Neither *Acacia harpophylla* forest nor SEVT communities mix with *Cadellia pentastylis* forest in NSW (Benson 1993), although all three plant communities share a number of species. The nearest *Cadellia pentastylis* occurrence, in the Gamilaroi Nature Reserve, is only 30 km to the west of Derra Derra (Fig. 1).

Derra Derra and Planchonella Hill share a number of western plains species but others such as *Ventilago viminalis*, *Casuarina cristata*, *Santalum lanceolatum* and *Maireana microphylla*, recorded from Planchonella Hill, appear to be absent from Derra Derra. The tree, *Planchonella cotinifolia* var *pubescens*, which is rare in NSW, has not been recorded south of Planchonella Hill and has not been recorded from Derra Derra. This species extends to north-central Queensland where it is more common (Forster et al. 1991). These differences in species composition may in part be explained by the fact that Derra Derra receives 100 mm more rainfall on average than Planchonella Hill.

The hypothesis of coastal origins for inland dry rainforests (Gillison 1987) holds true more at the generic than species level for the SEVT on the North Western Slopes of NSW. In contrast to the situation in inland north Queensland (Fensham 1995), few dry rainforest species present in SEVT in NSW (Table 2) are found on the coast. However, many genera in SEVT in NSW are shared between the inland and the coast. These include *Ehretia*, *Geijera*, *Notelaea*, *Parsonsia*, *Pittosporum*, *Clematis*, *Citriobatus*, *Croton* and *Alectryon*.

SEVT is one of the most restricted, threatened and poorly-reserved vegetation types in NSW (Benson 1989). The original extent of SEVT in NSW is unknown but it is likely that most of the stands have been cleared. Approximately 2500 ha of SEVT are left in NSW. Given their biogeographical interest and their restricted occurrence, the remaining stands of SEVT merit protection. Planchonella Hill with 450 ha of SEVT and Derra Derra with 1350 ha are the two most important remnants of SEVT in NSW. Few areas composed of basalt are protected in reserves on the western slopes of NSW. As mentioned, Planchonella Hill has recently been purchased for management as a nature reserve. Derra Derra should also be considered for dedication as a nature reserve. As a minimum, the Crown land area of 1500 ha should be protected. Unlike the SEVT at Planchonella Hill, the SEVT at Derra Derra Ridge is buffered from edge effects to some degree as it is part of a block of more than 4000 ha of natural vegetation. This may assist with long-term management. Stock should be fenced out from Derra Derra and other important vine thickets because heavy grazing and trampling may limit the regeneration of a range of plant species. Studies are required into the germination and seedling establishment of dry rainforest plant species that grow in vine thickets.

Table 2: Plant species recorded at Derra Derra Ridge and Planchonella Hill (1–7 = Derra Derra sample sites, H = recorded by Hull (1992) at Derra Derra, P = Planchonella Hill (Williams 1983), * = exotic species)

Species and family	1	2	3	4	5	6	7	H	P
Abutilon oxycarpum (Malvaceae)									X
Abutilon tubulosum (Malvaceae)								X	
Acacia cheelii (Fabaceae)	X	X		X					
Acacia deanei subsp. *deanei* (Fabaceae)		X			X				X
Acacia decora (Fabaceae)				X		X			
Acacia harpophylla (Fabaceae)							X		X
Acacia implexa (Fabaceae)			X						X
Acacia salicina (Fabaceae)	X		X	X	X				X
Alectryon oleifolius subsp. *elongatus* (Sapindaceae)									X
Alectryon subdentatus (Sapindaceae)	X		X						X
Alphitonia excelsa (Rhamnaceae)			X						X
Alstonia constricta (Apocynaceae)	X								X
Amyema cambagei (Loranthaceae)									X
Amyema miquelii (Loranthaceae)							X		X
Amyema miraculosum subsp. *boormanii* (Loranthaceae)									X
Angophora floribunda (Myrtaceae)			X						X
Aristida caput-medusae (Poaceae)									X
Aristida ramosa (Poaceae)	X	X	X	X	X		X		
Atalaya hemiglauca (Sapindaceae)	X								X
Beyeria viscosa (Euphorbiaceae)	X		X	X	X	X			X
Boerhavia dominii (Nyctaginaceae)		X	X	X					X
Brachychiton populneus subsp. *populneus* (Sterculiaceae)	X				X				X
Brachycome multifida var. *multifida* (Asteraceae)						X			
Breynia oblongifolia (Euphorbiaceae)	X					X		X	
Brunoniella australis (Acanthaceae)				X				X	
Callitris glaucophylla (Cupressaceae)		X	X	X		X			X
Canthium oleifolium (Rubiaceae)		X		X	X	X			X
Capparis lasiantha (Capparaceae)									X
Capparis mitchellii (Capparaceae)	X								X
Carex breviculmis (Cyperaceae)		X	X						
Carex inversa (Cyperaceae)					X				
Carissa ovata (Apocynaceae)	X	X	X	X	X		X		X
Cassine australis var. *angustifolia* (Celastraceae)	X	X	X	X	X		X		X

Species and family	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**H**	**P**
Cassinia laevis (Asteraceae)		X							X
Casuarina cristata (Casuarinaceae)									X
Chamaesyce drummondii (Euphorbiaceae)				X					
Cheilanthes distans (Sinopteridaceae)		X			X	X			
Cheilanthes sieberi subsp. *sieberi* (Sinopteridaceae)	X	X		X	X	X			
Chloris truncata (Poaceae)		X		X					
Citriobatus spinescens (Pittosporaceae)									X
Clematis glycinoides (Ranunculaceae)				X					
Clematis microphylla var. *microphylla* (Ranunculaceae)								X	X
Commelina cyanea (Commelinaceae)			X						
Correa glabra (Rutaceae)			X	X	X				
Croton phebalioides (Euphorbiaceae)							X		X
Cryptandra longistaminea (Rhamnaceae)		X	X	X					
Cymbidium canaliculatum (Orchidaceae)				X					X
Cymbopogon refractus (Poaceae)				X	X				
Dendrophthoe glabrescens (Loranthaceae)	X					X			
Desmodium brachypodum (Fabaceae)			X	X		X			
Dianella revoluta var. *revoluta* (Phormiaceae)			X	X					
Dichondra repens (Convolvulaceae)	X	X	X	X	X				
Dodonaea sinuolata subsp. *sinuolata* (Sapindaceae)				X					X
Dodonaea viscosa subsp. *angustifolia* (Sapindaceae)		X			X	X			X
Ehretia membranifolia (Boraginaceae)	X								X
Einadia hastata (Chenopodiaceae)	X								
Eremophila mitchellii (Myoporaceae)									X
Eucalyptus albens (Myrtaceae)			X		X				X
Eucalyptus dealbata (Myrtaceae)						X			
Eucalyptus melanophloia (Myrtaceae)		X	X	X		X			X
Eucalyptus pilligaensis (Myrtaceae)								X	
Eustrephus latifolius (Luzuriagaceae)			X						
Gahnia aspera (Cyperaceae)	X		X				X		
Galium migrans (Rubiaceae)					X				
Geijera parviflora (Rutaceae)	X	X	X		X		X		X
Gossypium sturtianum var. *sturtianum* (Malvaceae)									X
Euchiton sphaericus (Asteraceae)			X						
Gymnema pleiadenium (Asclepiadaceae)	X								X
Hovea lanceolata (Fabaceae)						X			X
Hovea longipes (Fabaceae)									X
Indigofera brevidens (Fabaceae)		X	X	X					
Isotropis foliosa (Fabaceae)						X			
Jasminum lineare (Oleaceae)									X
Kennedia prostrata (Fabaceae)								X	

Species and family	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**H**	**P**
Korthalsella rubra subsp. *geijericola* (Viscaceae)							X		X
Lomandra multiflora subsp. *multiflora* (Lomandraceae)		X	X						
**Lycium ferocissimum* (Solanaceae)									X
Lysiana exocarpi subsp. *exocarpi* (Loranthaceae)							X		X
Lysiana subfalcata (Loranthaceae)									X
Macrozamia stenomera (Zamiaceae)								X	
Maireana microphylla (Chenopodiaceae)									X
Marsdenia viridiflora (Asclepiadaceae									X
Maytenus bilocularis (Celastraceae)									X
Melaleuca bracteata (Myrtaceae)			X						
Mentha satureioides (Lamiaceae)									X
Myoporum montanum (Myoporaceae)									X
Notelaea microcarpa var. *microcarpa* (Oleaceae)	X	X	X	X	X	X			X
Olearia elliptica (Asteraceae)	X		X	X	X	X	X		X
**Opuntia stricta* var. *stricta* (Cactaceae)	X		X	X		X	X		X
**Oxalis thompsoniae* (Oxalidaceae)			X						
Pandorea pandorana (Bignoniaceae)	X		X	X	X				
Parsonsia eucalyptophylla (Apocynaceae)	X	X		X	X		X		X
Parsonsia lanceolata (Apocynaceae)									X
Pellaea falcata var. *falcata* (Sinopteridaceae)		X							
Phyllanthus subcrenulatus (Euphorbiaceae)	X	X	X						X
Pimelea microcephala (Thymelaeaceae)									X
Pimelea neo-anglica (Thymelaeaceae)	X	X	X	X	X		X		X
Pittosporum philliraeoides (Pittosporaceae)									X
Planchonella cotinifolia var *pubescens* (Sapotaceae)									X
Poa sieberiana var. *hirtilli* (Poaceae)	X	X	X						X
Pseuderanthemum variabile (Acanthaceae)				X					
Rostellularia adscendens subsp. *adscendens* (Acanthaceae)								X	
Santalum lanceolatum (Santalaceae)							X		
Senna coronilloides (Fabaceae)	X								X
Solanum parvifolium (Solanaceae)	X		X						X
Solanum semiarmatum (Solanaceae)			X						
Spartothamnella juncea (Chloanthaceae)		X	X				X		X
Stipa ramosissima (Poaceae)								X	
Swainsonia galegifolia (Fabaceae)								X	X
Thellungia advena (Poaceae)	X	X	X		X				
Triodia scariosa subsp. *scariosa* (Poaceae)						X			
Ventilago viminalis (Rhamnaceae)									X
Vittadinia cuneata (Asteraceae)				X					
Wahlenbergia gracilis (Campanulaceae)			X						
Zygophyllum sp. (Zygophyllaceae)									X

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The grassy balds on the Bunya Mountains, south-eastern Queensland: floristics and conservation issues

R.J. Fensham and R.J. Fairfax

Fensham, R.J., and Fairfax, R.J., (Queensland Herbarium, Department of Environment, Meiers Road, Indooroopilly, Queensland, Australia 4068) 1996. The grassy balds on the Bunya Mountains, south-eastern Queensland: floristics and conservation issues. Cunninghamia *4(3): 511–523.* Grassy balds occur on the Bunya Mountains, south-eastern Queensland (26°53'S, 151°34'E) in all topographic situations, surrounded by either eucalypt forest or rainforest and over an altitudinal range of 600–1100 m. An agglomerative clustering classification of the vascular flora of a sample of 59 of the 119 grassy balds derived three major groups: high altitude grassland on relatively shallow slopes (Group 1), mid- to high-altitude grassland on steep slopes (Group 3), and mid-altitude grassland (Group 4). *Poa labillardieri* is the most common dominant grass, although nearly 50% of Group 3 balds are dominated by either *Themeda triandra* or *Sorghum leiocladum*. Only about a quarter of the area of grassy balds occurring over 700 m and only 9 hectares, constituting less than 6% of those occurring under 700 m altitude, are reserved in the Bunya Mountains National Park. The four largest grassy balds occur outside the park. The rare species *Bothriochloa bunyensis*, *Haloragis exaltata* subsp. *velutina* and *Thesium australe* occur on the balds and their distribution and conservation status are discussed. Research from elsewhere indicates that *Thesium* is sensitive to grazing. Kikuyu (*Pennisetum clandestinum*), an exotic perennial grass, has the potential to completely replace native grassland species of the balds and an urgent management priority is its removal from those four balds where its extent is still limited. The wind-dispersed annual, Balloon cotton bush (*Gomphocarpus physocarpus*) is widespread on the balds, but does not appear to reduce native species richness. By 1991, about one quarter of the area of the balds in existence in 1951 had been transformed from grassland to forest or woodland. It is likely that the contraction of grassland coincides with a changed fire regime since the advent of European settlement. A fire management program should be developed that aims to minimize the invasion of forest species into the remaining grasslands.

Introduction

High-altitude grasslands (over 600 m) are not common in Queensland, because most montane areas are either of relatively oligotrophic substrate and support heathy vegetation or occur in areas of relatively high rainfall and support rainforest or tall eucalypt forest. There are grasslands on the Bunya Mountains (26°53'S, 151°34'E) , a north-westerly orientated basaltic massif on the Great Dividing Range 160 km WNW of Brisbane, in a variety of environmental situations within a matrix of rainforest and eucalypt forest (Webb 1964; Fensham & Fairfax in press). The grasslands known as 'balds' occur on a variety of aspects and slopes from the lower slopes and gullies at 600 m and cover the highest summit at 1100 m (Fensham & Fairfax in press). Some of these grasslands are protected within the Bunya Mountains National Park that covers 19450 ha (Fig. 1). Grasslands have been described as 'Australia's most threatened ecosystem' (Kirkpatrick et al. 1995) throughout southeastern Australia. Montane grassland balds occur at Wollemi National Park, Barrington Tops and Dorrigo in New South Wales in similar environmental setting to the Bunya Mountains (J. Benson pers. comm.), but have not been described in the literature. Except for description of their environmental setting and discussion of their origin (Webb 1964; Fensham & Fairfax in press) there are also no published accounts of the vegetation of the grassy balds on the Bunya Mountains.

This paper seeks to describe the vegetation of the grassy balds of the Bunya Mountains using a numerically derived community typology. Conservation issues are assessed, including the botanical significance of the grasslands and ecological significance as probable anthropogenic artefacts. Management issues are discussed including those related to to the control of exotic plants and the use of fire as a tool to shape the composition and extent of the balds.

Methods

Field methods

The Bunya Mountains balds were mapped from aerial photographs (1: 25 000) taken in 1991. Fifty-nine balds out of a total of 119 were visited between January 1995 and April 1995, a period covering the flowering of most of the herbaceous flora. The sampled balds were selected to cover the range of environmental positions occupied by balds on the Bunya Mountains. Species nomenclature follows Henderson (1994). At each site all the vascular plant species occurring in a 10 × 2 m quadrat were recorded. Each quadrat was placed in what was assessed to be the most representative topographic position, slope and aspect for that bald. Other species within the bald were noted, which in combination with the quadrat list gives an overall list for the bald. The dominant grass was recorded and the abundance of the exotic grass Kikuyu (*Pennisetum clandestinum*) was assessed on the scale: 0 = absent; 1 = restricted to the edges of tracks; 2 = extending from tracks, but less than 50% of bald area invaded; 3 = more than 50% bald area invaded. The abundance of the tall exotic herb Balloon cotton bush (*Gomphocarpus physocarpus*) in each bald was assessed on the scale: 1 = absent; 2 = very sparse; 3 = common in localised situations; 4 = common and widespread.

The following data were collected for each sampled bald:

a) Location (Australian Map Grid co-ordinates from the 1: 50 000 map);
b) Mid-altitude (halfway between the lowest and highest elevations from 1: 50 000 map);
c) Modal slope (estimated according to the scale; flat (0–2%), gentle (3–8%), moderate (9–20%), steep (21–35%), very steep (> 35%);
d) Modal landscape position (ridgetop, mid-slope, footslope, valley/plain);
e) Most common surrounding vegetation (eucalypt forest, rainforest);

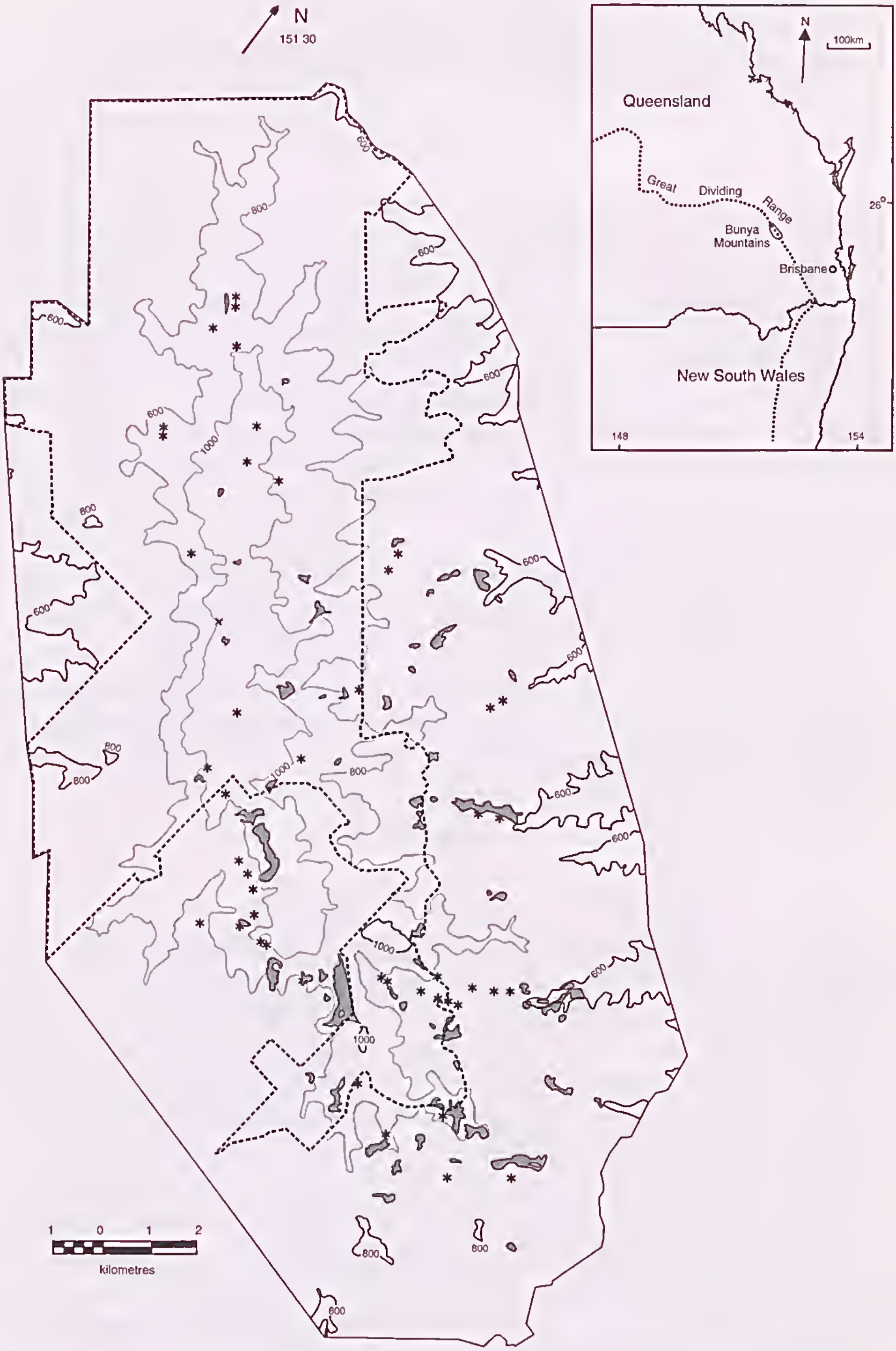

Fig. 1. Locality map showing the topography of the Bunya Mountains and the position of the balds in 1991. Balds too small to map are marked with an asterisk. The dashed line marks the boundary of the National Park.

f) The overall area in 1991, measured from aerial photographs, using 1 mm graph paper;

g) Surface rock cover (estimated according to the scale; absent, 0–5, 5–20, 20–50, > 50% of the surface area).

Analytical methods

The data were stored and manipulated within the DECODA software (Minchin 1991). The PATN software (Belbin 1988) was used for the classification using the group average procedure flexible-UPGMA (Unweigthed Pair Group using Arithmetic Averaging; see Sneath & Sokal 1973), a hierarchical agglomerative multivariate clustering technique that compares favourably in comparisons with other techniques given the task of recovering known configurations from generated data (Belbin et al. 1992; Belbin & McDonald 1993). The analysis was performed on presence–absence data for native species only, using the overall site list, following the removal of woody species with a mature height greater than 2 m, and the default settings in PATN that does not delete rare species and sets the dilation of the multivariate space at a recommended value (Belbin et al. 1992).

For the continuous variables differences between groups were tested using analysis of variance following ln (x + 1) transformation. For categorical variables the environmental association of groups was tested using the chi-squared test.

Native species richness was compared between those balds with *Gomphocarpus* abundance ratings of ≤ 2 and ≥ 3, using a t-test without any transformation given that a test showed that the species richness data was heteroscedastic.

Results

Community classification and description

The fifty-nine sampled balds represent about half of 119 extant grassy balds on the Bunya Mountains (Fig. 1). The balds are generally tussock grasslands (Fig. 2) and most frequently dominated by *Poa labillardieri* which is a common dominant of temperate grasslands and is near its northern limit on the Bunya Mountains. On this basis the balds may be regarded as a northern isolate of a temperate grassland type, although only 26 (15%) of the native vascular plant species have their known northern limit within 100 km of the Bunya Mountains (HERBRECS database, Queensland Herbarium).

All of the species known from the Queensland Herbarium database (HERBRECS) were relocated during this survey suggesting that although some spring geophytes may await discovery, the flora of the balds has been generally well sampled during this study. The recorded flora of the grassy balds, excluding trees, consists of 181 native taxa including subspecies (Appendix). The dendrogram was accepted at the five-group level, given that exploratory analysis indicated that lower levels of the hierarchy could not be distinguished on environmental grounds (Fig. 2). The full species list and percentage frequency of occurrence in the five UPGMA groups are presented in the Appendix. Thirty-four exotic taxa were present on the balds and

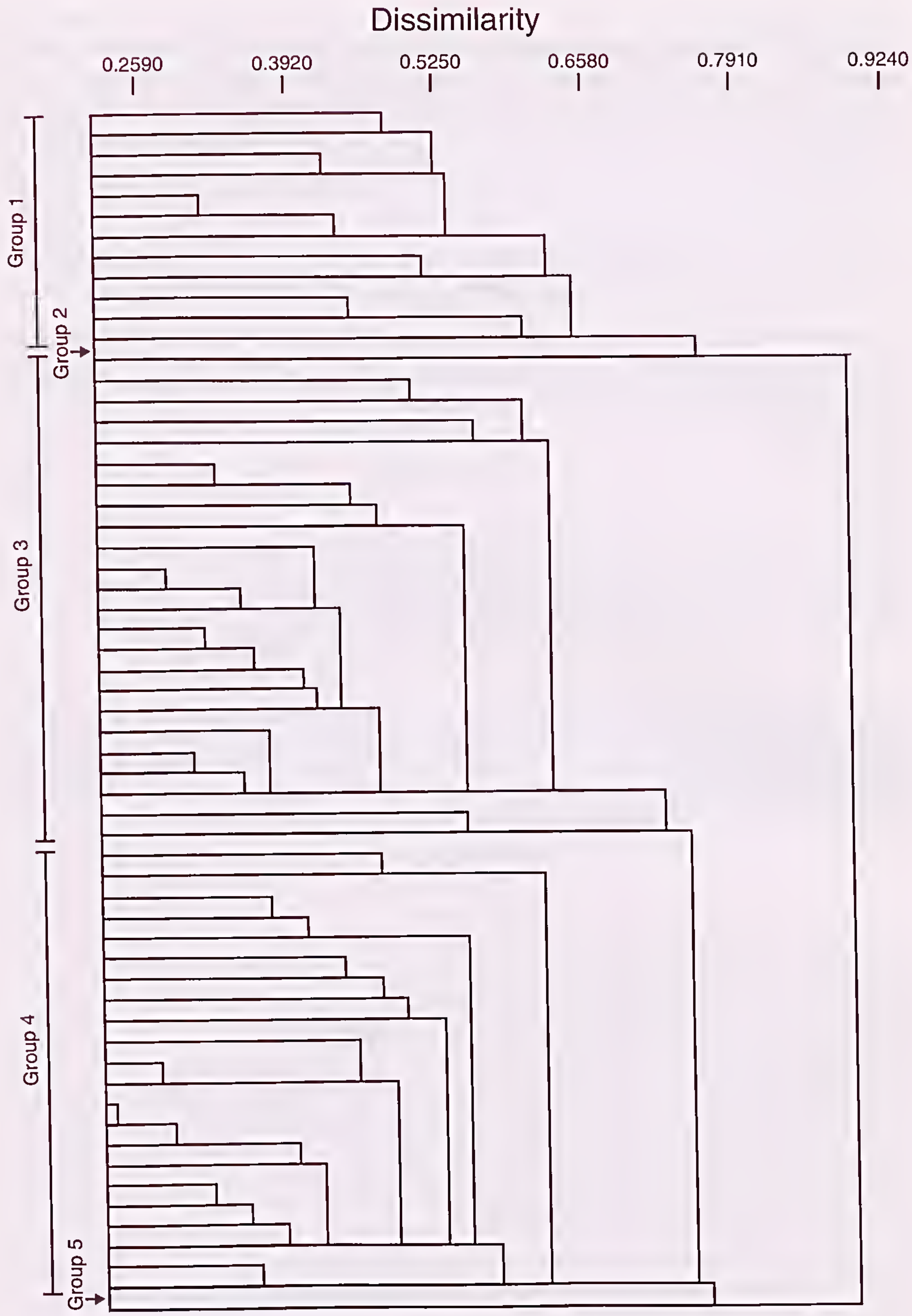

Fig. 2. UPGMA classification dendrogram.

these were excluded from the analysis. There was no association of the UPGMA groups with aspect according to the chi-squared test ($P > 0.05$) but the groups were positively associated with the landscape position categories (Table 1; chi-square = 22.9; $P < 0.001$). The association of the UPGMA groups with those bald characteristics on continuous numerical scales and the significance of differences between groups are shown in Table 2, and the associated frequency of the grass dominants with the groups is shown in Table 3.

Group 1 comprises relatively small balds at high altitude that have significantly lower slope angles than the only other relatively high altitude community (Group 3) having

Table 1. Association of UPGMA classificatory groups according to landscape position categories.

	UPGMA group					
	1	**2**	**3**	**4**	**5**	**Total**
Ridgetop	2	0	12	7	1	22
Midslope	7	1	9	4	0	21
Footslope	1	0	0	5	0	6
Valley/Plain	2	0	0	8	0	10
Total	12	1	21	24	1	59

Table 2. Mean values for seven characteristics of the sampled balds subdivided according to UPGMA classificatory group. The F values and significance of differences from oneway ANOVA are also shown. Groups 2 and 5 were not included in the comparison because they consist of single sites. Mean values between pairs of groups that are not significantly different according to Tukey's test are enumerated with the same letter.

	UPGMA group					ANOVA results	
	1	**2**	**3**	**4**	**5**	**df, error**	**F value**
Size 1991 (ha)	1.0^{A}	10.0	8.0^{B}	6.0^{B}	3.2	2, 53	8.77***
Altitude (m)	986^{A}	1015	862^{B}	685^{C}	988	2, 53	50.72***
Slope (%)	7.0^{A}	1.0	22.1^{B}	6.8^{A}	1.0	2, 53	10.88***
Rock cover (%)	8.8^{A}	2.5	8.8^{A}	3.3^{A}	12.5	2, 53	NS
Gomphocarpus physocarpus extent (see Methods)	2.2^{A}	3.0	2.8^{AB}	3.0^{B}	3.0	2, 53	3.24*
No. of native species	26.9^{A}	9.0	37.5^{B}	34.6^{B}	47.0	2, 53	6.57**
No. of exotic species	3.3^{A}	3.0	5.7^{B}	4.3^{AB}	8.0	2, 53	5.50**

*** $P < 0.001$; ** $P < 0.01$; * $P < 0.05$; NS $P > 0.05$

Table 3. The dominant grass species of the sampled balds according to UPGMA classificatory group.

	UPGMA group				
Dominant species	**1**	**2**	**3**	**4**	**5**
Poa labillardieri	11	1	11	17	1
Themeda triandra	0	0	6	0	0
Sorghum leiocladum	1	0	4	7	0

sufficient members for statistical testing. Group 1 balds are almost exclusively dominated by *Poa labillardieri* and are relatively species-poor compared with the other larger groups. The sedge *Carex declinata* is the strongest indicator of this group although it is not always present and can occur in other groups.

Group 2 is a single site at 1015 m altitude dominated by *Poa labillardieri* and it is distinguished form other groups by its low species richness rather than by any particularly faithful species associates. The site is outside the National Park and amongst housing development, but despite these circumstances the reason for the depauperate species composition of this site is not known.

Group 3 sites are mid- to high-altitude, relatively large balds and were only sampled on ridgetops and midslopes. Mean slope angles are considerably higher than for the other groups. The balds comprising this group are relatively species-rich and can be dominated by *Poa labillardieri, Sorghum leiocladum* or *Themeda triandra*. The herbaceous daisies *Bracteantha bracteata, Chrysocephalum apiculatum* and *Picris angustifolius* are faithful indicators for the group.

Group 4 sites are distinguished from other groups because they occupy mid-altitudes, but can occupy a variety of landscape positions. *Poa labillardieri* and *Sorghum leiocladum* dominate these balds. The grasses *Aristida ramosa* and *Panicum effusum* var. *simile*, and the low shrub *Sida subspicata* are frequent associates of this group, and are relatively infrequent or absent in other groups.

Group 5 consists of one bald situated on a high-altitude ridgetop and is 3 km from the nearest bald in the north-west of the study area. The grasses *Chloris divaricata* and *Tripogon loliiformis*, the sedge *Cyperus squarrosus*, the herbs *Hibiscus trionum, Portulaca bicolor, Rhodanthe anthemoides, Solenogyne bellioides* and *Velleia paradoxa* are all either infrequent in or absent from all other groups (Appendix).

Land tenure

The almost total eradication of low altitude grasslands by cultivation in the Darling Downs (Fensham submitted) mirrors the plight of this vegetation type throughout south-eastern Australia (Kirkpatrick et al. 1995). The rarity of lowland grassland confers great conservation value to the low altitude balds on the Bunya Mountains. Unfortunately the nine hectares of grassy bald at less than 700 m altitude in the Bunya Mountains National Park (Table 4) represents the only reservation of low altitude grassland in south-east Queensland. Even the high altitude balds are poorly represented in the National Park with only 27% of their area in the National Park (Table 4) and the four largest balds are outside the park boundary (Fig. 1). Alone of the five groups of balds defined earlier, Group 2 does not occur in the National Park and Group 4 is extremely poorly represented.

The grassy balds in State Forest on the north-eastern flanks of the Bunya Mountains are not effectively managed for conservation as domestic cattle herds are present in these areas under the provision of grazing leases. The inclusion of these areas to the National Park would greatly improve the reservation status of grassland in Queensland and allow for appropriate management (see below).

Rare species

Three species on the Bunya Mountains balds are listed on the protected plant schedule of the *Nature Conservation (Wildlife) Regulation 1994, Subordinate Legislation no. 474 of 1994* (Queensland) and all three are also listed by Briggs and Leigh (1988). The grass *Bothriochloa bunyensis* was first discovered on the Bunya Mountains where it is relatively widespread (Appendix). It has since been found on a grassy bald on a basaltic section of the Great Dividing Range 175 km to the south-east of the Bunya Mountains; it appears to be endemic to montane grasslands in south-east Queensland.

Thesium australe is a herbaceous root parasite (principally of *Themeda triandra*) recorded from two Group 4 sites, one population of one individual of which was noted in the National Park. The species is listed in Queensland as vulnerable where it is rare in remnant grassy vegetation mostly on roadsides and rail reserves in the Darling Downs district. Its general absence from paddocks grazed by domestic stock suggests that the species is probably sensitive to grazing (Griffith 1992; Fensham unpublished data). The vast reduction in its inland grassy habitat from south-east Queensland to Tasmania (where it is now considered extinct — Kirkpatrick et al. 1991) confers considerable conservation significance on populations in the Bunya Mountains grassy balds. The largest known population on the Bunya Mountains is on a bald in State Forest that is largely inaccesible to cattle. Little is known of the fire ecology of *Thesium australe* (Griffith 1992), although its response to a single fire is currently the target of investigation (J. Cohn pers. comm.).

Haloragis exaltata subsp. *velutina* was found on one group 5 site and is restricted to northern New South Wales and south-eastern Queensland where its primary habitat seems to be the margins of rainforest. The species grows to about 1 m which is much larger than most members of the Haloragaceae. There is little recorded information of the ecology of the species.

Exotic species

The flora of the Bunya Mountains balds includes 34 exotic species. Of all of these species, the rhizomatous grass *Pennisetum clandestinum* poses the greatest threat to the natural integrity of the grasslands. It has the capacity to almost completely replace native species and to form monospecific swards that are maintained as lawns by wallaby grazing (mostly red-necked wallaby). Expansive exotic lawns dominated by the species almost totally occupy two balds and *Pennisetum clandestinum* is displacing intact native grassland in another two balds. It is also present on disturbed ground in another four

Table 4. Areas (ha) and percentages of balds in two altitude classes on the Bunya Mountains according to land tenure categories.

	Land tenure			
Altitude class	**National Park**	**State Forest**	**Freehold land**	**Total area**
Low altitude (590–700 m)	8.8 (5.5%)	130.8 (82.5%)	19.0 (12.0%)	158.6 (100%)
High altitude (701–1140 m)	69.4 (27.2%)	70.9 (27.8%)	115.0 (45.0%)	255.3 (100%)
Total	78.2 (18.9%)	201.6 (48.7%)	134.0 (32.4%)	413.8 (100%)

balds, two of which are the largest balds on the mountains. It would be probably be a futile task to try to eradicate the species from the balds where it dominates large areas. However, it is of the utmost management priority that attempts are made to eradicate *Pennisetum clandestinum* from the four balds which currently have minor infestations. Unfortunately, three of the four minor occurrences are on land of freehold title.

Gomphocarpus physocarpus is extremely widespread and occurs in all groups except the single site forming Group 2 (Appendix). Both correlation and the t-test indicated greater native species richness in balds with *Gomphocarpus* bush invasion, although differences were not significant ($P > 0.05$).

Gomphocarpus is a wind-dispersed ephemeral and anecdotal evidence suggests that it can become abundant following fire (D. Sansom pers. comm.). However, its density decreases as the tussock grasses and intertussock species increase their cover during the post-fire interval.

There are two perennial exotic grasses (*Eragrostis curvula* and *Setaria sphacelata* var. *sericea*) that are not widespread on the Bunya Mountains, but that may have the ability to dominate grassland and invade without the stimulant of mechanical disturbance. The former of these species poses a major management problem in grasslands of the Monaro district of New South Wales (J. Benson pers. comm.) and the small isolated populations of both these grasses should be a priority for eradication.

Most of the other herbaceous exotic plants are relatively innocuous intertussock species that do not seem to displace native species (e.g. *Centaurium erythraea*, *Conyza bonariensis*, *Veronica bonariensis*). Others are invaders of disturbed areas (e.g. *Chloris virgata*, *Tagetes minuta*) and present no major threat to the native vegetation of the balds given current park management that attempts to minimize such disturbance.

Two woody exotics, *Lantana camara* and groundsel bush *Baccharis halmifolia* are occasional invaders of grassy balds, although they are relatively rare compared to native trees and shrubs (see below).

Forest invasion

Fensham & Fairfax (in press) indicate that 26% of the area of balds on the Bunya Mountains has been invaded by woody forest species during the period 1951–1991. The most common invading species are *Acacia implexa*, *A. irrorata*, *A. maidenii*, *Cassinia laevis*, *C. quinquefaria* and *Eucalyptus tereticornis*.

The rapid rate of forest invasion is incompatible with a hypothesis explaining the existence of balds as remnants of a Holocene climate (e.g. Webb 1964). Fensham & Fairfax (in press) have argued that most balds on the Bunya Mountains are disclimax communities resulting primarily from aboriginal burning. If this view is correct the Bunya Moutains balds have cultural as well as biological values and the case for management directed to their maintenance is strengthened. The decision to manage for the maintenance of a vegetation type of limited occurence or to allow natural succession to take its path is in the end a philosophical question. However, the question has been addressed in the Southern Appalachians, and based on aesthetic, cultural heritage and biodiversity values a management policy using fire for bald maintenance has been recommended (Lindsay & Bratton 1979). Such a policy on the Bunya Mountains would require determination of the optimum fire regime. Fire management should not only aim to restrict the spread of woody species but should also aim to minimise the establishment of balloon cotton bush. The senior author, in conjunction with the rangers in the National Park, is embarking on a simple monitoring procedure seeking to relate post fire reduction in woody species and ballon cotton bush with seasonal, environmental and weather conditions during burning of grassland on the Bunya Mountains.

Appropriate fire management must be employed regardless of tenure for the range of grassy balds on the Bunya Mountains to survive. Positive public perception of fire in grasslands may need to be nurtured given the high visitation rates to this National Park and the experience elsewhere of visitors reacting negatively to fire in conservation areas.

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Appendix

Percentage frequency of vascular plant taxa according to UPGMA classificatory group. Number of balds in each group: Group 1 = 12, Group 2 = 1, Group 3 = 21, Group 4 = 24 and Group 5 = 1.

	UPGMA group				
	1	**2**	**3**	**4**	**5**
PTERIDIOPHYTA					
Adiantaceae					
Adiantum aethiopicum	8	–	5	–	–
Adiantum capillusveneris	–	–	5	–	–
Blechnaceae					
Doodia aspera	8	–	–	–	–
Dennstaedtiaceae					
Pteridium esculentum	17	–	19	4	–
Dryopteridaceae					
Lastreopsis decomposita	8	–	–	4	–
Ophioglossaceae					
Botrichium australe	8	–	10	–	–
Ophioglossum lusitanicum	25	–	–	25	100
Sinopteridaceae					
Cheilanthes distans	33	–	24	8	–
Cheilanthes sieberi	42–	52	50	–	
ANGIOSPERMAE					
Acanthaceae					
Pseuderanthemum variable	8	–	10	4	–
Rostelullaria adscendens	–	–	–	42	–
Amaranthaceae					
Alternanthera nana	33	–	5	21	–
Alternanthera nodiflora	–	–	–	4	–
Nyssanthes diffusa	25	–	19	4	–
Apiaceae					
Centella asiatica	17	–	5	8	100
Ciclospermum leptophyllum	8	–	10	13	–
Daucus glochidiatus	–	–	9.5	–	–
Hydrocotyle laxiflora	100	100	100	79	100
Araceae					
Typhonium brownii	8	–	–	4	–
Asclepiadaceae					
*Araujia sericifera**	–	–	5	–	–
Cynanchum bowmanii	–	–	–	4	–
*Gomphocarpus physocarpus**	75	–	95	92	100
Asteraceae					
*Bidens pilosa**	8	–	19	–	–
Brachyscome microcarpa	17	–	67	25	100
Bracteantha bracteata	8	–	81	–	–
Calotis lappulacea	–	–	–	8	–
*Carduus thoermeri**	8	–	10	4	–
Centipeda minima	–	–	–	4	–
Chrysocephalum apiculatum	–	–	62	13	–
*Cirsium vulgare**	50	100	48	33	–
*Conyza bonariensis**	8	–	88	29.2	100
*Erechtites valerianifolia**	–	–	5	–	–
Euchiton sphaericus	33	–	24	13	–
Euchiton sp.	8	–	10	–	–
Glossocardia bidens	–	–	19	29	–
Hypochoeris microcephala var. *albiflora**	–	100	5	13	100
*Hypochoeris radicata**	8	–	33	8	–
Lagenifera stipitata	–	–	5	–	–
Picris angustifolius	–	–	67	–	–
Podolepis jaceoides	–	–	19	–	–
Rhodanthe anthemoides	–	–	–	–	100
Schkuhria pinnata var. *abrotanoides**	–	–	–	4	
Senecio hispidulus	8	–	19	17	–
Senecio quadridentatus	–	–	5	4	–
Sigesbeckia orientalis	8	–	14	4	–
Solenogyne bellioides	–	–	–	4	100
Sonchus oleraceus	–	100	14	–	–
*Tagetes minuta**	–	–	5	13	–
Vittadinia dissecta var. *dissecta*	–	–	–	13	–
Vittadinia sulcata	–	–	5	21	100
Vernonia cinerea	–	–	29	38	–
Wedelia spilanthoides	–	–	10	–	–
*Zinnia peruviana**	–	–	–	13	100
Bignoniaceae					
Pandorea pandorana	8	–	10	4	–
Boraginaceae					
Cynoglossum suaveolens	8	–	–	–	–
Brassicaceae					
Cardamine hirsuta	17	–	14	8	100
*Lepidium africanum**	–	–	–	–	100
Cactaceae					
*Opuntia stricta**	8	–	10	201	100
Caesalpineaceae					
Senna barclayana	17	–	–	50	–
Campanulaceae					
Wahlenbergia gracilis	67	–	100	96	100
Caryophyllaceae					
*Polycarpon tetraphyllum**	8	–	–	–	–
Chenopodiaceae					
Chenopodium pumilio	33	100	5	25	–
Einadia hastata	25	–	14	8	–
Clusiaceae					
Hypericum gramineum	8	–	81	29	–
Commelinaceae					
Commelina cyanea	75	100	52	25	100
Murdannia graminea	–	–	–	4	100
Convolvulaceae					
Convolvulus erubescens	–	–	4	–	–
Dichondra repens	8	–	14	42	–
Evolvulus alsinoides	–	–	14	25	–
Ipomoea plebeia	–	–	–	4	–
Crassulaceae					
Crassula sieberiana	17	–	19	–	100
Cyperaceae					
Carex breviculmis	8	–	52	33	–
Carex declinata	83	–	33	17	–
Carex inversa	8	–	33	63	100

	UPGMA group				
	1	2	3	4	5
Cyperus fulvus	33	–	62	88	100
Cyperus gracilis	67	–	52	75	–
Cyperus laevis	8	–	10	–	–
*Cyperus sesquiflorus**	–	–	–	4	–
Cyperus sphaeroideus	17	–	–	–	–
Cyperus squarrosus	–	–	–	–	100
Fimbristylis dichotoma	42	–	67	88	100
Fimbristylis nutans	–	–	5	–	–
Lepidosperma laterale	–	–	29	–	–
Scleria mackaviensis	8	–	10	17	–
Epacridaceae					
Lissanthes strigosa	–	–	–	4	–
Euphorbiaceae					
Euphorbia dallachyana	–	–	5	13	–
Euphorbia drummondii	–	–	5	–	–
Phyllanthus virgatus	–	–	48	63	10
Poranthera microphylla	–	–	10	–	–
Fabaceae					
Crotalaria mitchellii subsp. *laevis*	–	–	10	13	–
Crotalaria mitchellii subsp. *mitchellii*	–	–	5	–	–
Crotalaria montana	–	–	–	4	–
Desmodium brachypodum	–	–	29	13	–
Desmodium varians	8	–	71	63	–
Glycine clandestina	17	–	29	8	–
Glycine latifolia	8	–	38	21	–
Glycine tabacina	42	–	71	42	–
Lespedeza juncea	8	–	86	58	–
*Trifolium repens**	8	–	5	–	–
Zornia dyctiocarpa	–	–	33	21	–
Gentianaceae					
*Centaurium erythraea**	17	–	29	33	–
Geraniaceae					
Geranium solanderi	42	–	67	58	100
Goodeniaceae					
Velleia paradoxa	–	–	5	–	100
Haloragaceae					
Haloragis exaltata subsp. *velutina*	–	–	–	4	–
Haloragis heterophylla	8	–	14	4	–
Juncaceae					
Juncus aridicola	8	–	–	–	–
Juncus continuus	25	–	–	4	–
Juncus homalocaulis	–	–	–	4	–
Juncus usitatus	92	100	14	29	–
Luzula flaccida	–	–	10	–	–
Lamiaceae					
Ajuga australis	–	–	24	13	100
Mentha gracilis	42	–	19	25	–
Plectranthus graveolens	8	–	19	–	–
Plectranthus parviflorus	50	–	62	13	100
Salvia plebeia	–	–	–	17	–
Scutellaria humilis	–	–	10	–	–
Teucrium argutum var. *incisum*	33	–	24	25	–
Liliaceae					
Arthropodium milleflorum	–	–	29	–	–
Dianella longifolia	33	–	29	42	100
Dianella revoluta	25	–	47	33	–
Hypoxis hygrometrica	33	–	5	–	–
*Lilium formosanum**	–	–	5	–	–
Thysanotus tuberosus	–	–	14	–	–
Tricoryne elatior	–	–	–	17	100
Linaceae					
Linum marginale	–	–	–	4	–
Lobeliaceae					
Lobelia purpurascens	50	–	33	75	–
Malvaceae					
Hibiscus trionum	–	–	–	–	100
*Malvastrum americanum**	–	–	–	13	–
*Modiola caroliniana**	–	–	–	4	–
Sida rhombifolia	–	–	5	4	–
Sida subspicata	–	–	14	71	–
Menispermiaceae					
Stephania japonica	8	–	–	–	–
Nyctaginaceae					
Boerhavia dominii	–	–	–	4	–
Onagraceae					
Epilobium billardierianum subsp. *cinereum*	42	100	48	50	–
Epilobium billardierianum subsp. *hydrophilum*	8	–	14	4	–
Orchidaceae					
Dipodium pulchellum	–	–	5	–	–
Pterostylis sp.	–	–	5	–	–
Oxalidaceae					
Oxalis corniculata	67	–	81	92	–
Philesiaceae					
Eustrephus latifolius	–	–	10	8	–
Geitonoplesium cymosum	–	–	10	–	–
Phytolaccaceae					
*Phytolacca octandra**	8	–	–	4	–
Plantaginaceae					
Plantago debilis	17	–	–	21	100
Poaceae					
Aristida ramosa	–	–	–	50	–
Bothriochloa bunyensis	25	–	5	17	–
Bothriochloa decipiens	–	–	–	8	–
Bothriochloa macra	8	–	–	33	100
Capillipedium parviflorum	–	–	14	13	–
*Cenchrus caliculatus**	–	–	19	4	–
Chloris divaricata	8	–	–	4	100
Chloris ventricosa	–	–	–	8	–
*Chloris virgata**	–	–	–	4	100
Cymbopogon refractus	–	–	65	83	100
Danthonia racemosa var. *obtusa*	–	–	–	4	–
Danthonia racemosa var. *racemosa*	–	–	5	–	–
Dichanthium sericeum	–	–	–	25	100
Dichanthium tenue	–	–	24	13	–
Dichelachne crinita	–	–	48	33	100
Dichelachne rara	–	–	14	–	100
Digitaria brownii	33	–	62	71	–
Digitaria diffusa	17	–	10	–	100
*Echinochloa frumentacea**	–	–	–	4	–
Echinopogon ovatus	–	–	–	8	–
Enneapogon gracilis	–	–	–	8	–
*Eragrostis curvula**	–	–	10	4	100
Eragrostis leptostachya	8.	–	5	21	–

	UPGMA group				
	1	**2**	**3**	**4**	**5**
Eriochloa procera	–	–	–	4	–
Imperata cylindrica	25	–	38	38	–
*Melinis repens**	–	–	5	–	–
Microlaena stipoides	67	–	19.	21	100
Oplismenus aemulus	17	–	5	–	–
Panicum effusum var. *simile*	8	–	–	50	–
Panicum queenslandicum	–	–	–	4	–
Paspalidium aversum	8	–	–	–	–
Paspalidium disjunctum	–	–	–	17	–
Paspalidium gracile	–	–	5	38	–
*Paspalum dilatatum**	17	100	14	4	100
Pennisetum alopecuriodes	8	–	–	4	–
*Pennisetum clandestinum**	17	–	5	–	–
Poa labillardieri	10	100	96	100	100
Setaria sphacelata var. *sericea**	–	–	–	4	–
Sorghum leiocladum	42	–	91	88	–
Sporobolus elongatus	33	–	57	54	100
Stipa ramosissima	8	–	5	–	–
Stipa scabra	–	–	–	12.5	–
Themeda triandra	17	–	91	42	100
Tripogon loliiformis	–	–	45	4	100
Polygalaceae					
Polygala japonica	–	–	14	8	–
Polygonaceae					
Rumex brownii	100	–	57	67	100
Portulacaceae					
Portulaca bicolor	–	–	–	–	100
Portulaca oleracea	–	–	–	8	100
Primulaceae					
*Anagallis arvensis**	8	–	19	–	–
Ranunculaceae					
Ranunculus lappaceus	33	–	57	13	100
Rosaceae					
Acaena anserinifolia	17	–	38	4	–
Rubus parvifolius	50	–	86	50	–
Rubiaceae					
Asperula conferta	25	–	38	25	100
Galium ciliare	8	–	52	–	–
Galium migrans	50	–	33	21	–
Santalaceae					
Thesium australe	–	–	10	–	–
Scrophulariaceae					
Mimulus gracilis	8	–	–	4	100
*Verbascum virgatum**	–	–	10	17	–
Veronica plebeia	42	–	24	38	–
Solanaceae					
*Solanum nigrum**	25	–	19	29	100
Solanum parvifolium	16	–	29	17	–
Solanum stelligerum	–	–	5	–	–
Solanum furfuraceum	17	–	–	–	–
Stackhousiaceae					
Stackhousia viminea	–	–	24	21	–
Thymeleaceae					
Pimelea neoanglica	25	–	10	25	–
Urticaceae					
Urtica incisa	58	100	5	4	–
Verbenaceae					
*Verbena bonariensis**	412	100	62	25	–
*Verbena officinalis**	33	–	62	49	–
*Verbena tenuisecta**	–	–	5	4	–
Violaceae					
Hybanthus stellarioides	8	–	71	79	100
Viola betonicifolia	33	–	48	33	–
Vitaceae					
Cayratia clematidea	67	–	43	33	–
Xanthorrhoeaceae					
Lomandra filiformis	–	–	–	4	–
Lomandra longifolia	17	–	24	8	100

* exotic plant taxa

Vegetation and flora of swamps on the Boyd Plateau, Central Tablelands, New South Wales

P.G. Kodela, T.A. James and P.D. Hind

Kodela, P.G., James, T.A. and Hind, P.D. (Royal Botanic Gardens, Mrs Macquaries Road, Sydney, New South Wales, Australia, 2000). Vegetation and flora of swamps on the Boyd Plateau, Central Tablelands, New South Wales. Cunninghamia *4(3): 525–530.* The vegetation of several high-altitude swamps on the Boyd Plateau (33°57'S, 150°03'E) in Kanangra–Boyd National Park is briefly described. A species list is provided for Belarah, Boyd Hill, Dingo and Wheengee-whungee Swamps. These plateau swamps contain a complex of wet heath, sedgeland, herbfields, *Sphagnum* mossland and shallow water pools and streams. Over 90 native plant taxa were recorded during a survey undertaken in late February. Several rare and/or restricted species were identified, including *Boronia deanei, Prasophyllum rogersii* and *Restio longipes.*

Introduction

A cluster of distinctive wetlands described as the Boyd Plateau Bogs occur on the Boyd Plateau (33°57'S, 150°03'E) in Kanangra–Boyd National Park, 30 km south-east of Oberon, New South Wales (see Keith & Benson 1988). They are restricted to high altitudes, c. 1200 m, and have developed within headwater gullies in peat and peaty soils overlying granite. A reconnaisance vegetation survey of several swamps was undertaken on the 23 and 24 February 1995. The swamps investigated ranged from 0.4 to 1.4 km long. Descriptions of vegetation structure follow Specht (1970).

Vegetation

Keith & Benson (1988) recognised two structural vegetation types in the 'Boyd Plateau Bogs'. They identified a closed-sedgeland community dominated by *Carex appressa, C. gaudichaudiana, Juncus fockei* and *Baeckea utilis*, and a closed-heath community with the main canopy species *Leptospermum myrtifolium, L. obovatum* and *L. lanigerum*. Black (1982) compares several swamps, described as bog complexes, on the plateau and how their vegetation relates to clearing, burning and grazing histories/regimes.

The swamps investigated in this survey contained a complex of heath, sedgeland, herbfields, *Sphagnum* mossland and shallow water pools and streams, related primarily to local drainage patterns, but probably also affected by disturbance as a result of fire and grazing history. The dominant communities recognised are closed-sedgeland or open-heath with a sedgeland understorey. The sedgeland communities often contain characteristic hummocks, formed by the tufted habit of several swamp species, including species of *Restio* and *Xyris*. Dominant sedges include *Restio australis, Empodisma minus, Xyris ustulata* and sometimes *Carex gaudichaudiana*. Within the heath vegetation there are often patches of closed-sedgeland, sometimes with scattered shrubs. The open-heath is dominated by *Leptospermum myrtifolium*, *L. obovatum*, *Baeckea utilis*, *Callistemon pityoides*, *Epacris paludosus* and *Hakea microcarpa*. Small patches dominated by *Carex appressa*, *Bracteantha bracteata* and *Wahlenbergia ceracea* were also observed. Herbfields (and small areas of *Sphagnum* mossland) occur in damp soaks and are common on stream banks. Closed-heath/scrub often occurs on the swamp margins and along narrow, shallow streams. Below these taller shrub canopies there are sedges or open, shallow water with small herbs. Occasionally small eucalypt trees, particularly *Eucalyptus pauciflora*, encroach onto the swamp near the margins.

Over 90 native species were recorded (Table 1), including 6 species of conservation significance (Table 2). Very few introduced taxa occur in the swamps. *Hypochaeris radicata*, *Taraxacum officinale*, *Trifolium repens* and *Holcus lanatus* were most commonly observed. *Hypochaeris radicata* was growing amongst *Sphagnum* moss and in other very damp areas, indicating its tolerance to moist conditions.

Table 1. Plant species recorded from several swamps on the Boyd Plateau

Belarah Swamp (B): 33°54'S, 150°04'E, 1180–1190 m alt.; Boyd Hill Swamp (BH): 33°57'S, 150°01'E, 1230 m alt.; Dingo Swamp (D): 33°59'S, 150°02'E, 1170–1180 m alt.; Wheengee-whungee Swamps (W): 34°00'S, 150°02'E, 1190 m alt.

MOSS				
Sphagnaceae				
Sphagnum sp.	B	BH	D	W
FERNS				
Blechnaceae				
Blechnum nudum	B			
Dennstaedtiaceae				
Pteridium esculentum (swamp margin only)			D	
Gleicheniaceae				
Gleichenia dicarpa	B			
DICOTS				
Apiaceae				
Centella cordifolia	B	BH		W
Hydrocotyle peduncularis[1] form A	B	BH	D	W
H. peduncularis[1] form B		BH		
Lilaeopsis polyantha		BH		
Xanthosia dissecta	B			
Asteraceae				
Brachycome scapigera		BH		
Bracteantha bracteata species complex	B	BH	D	W
Celmisia longifolia species complex	B	BH		W
Craspedia canens	B			
Euchiton involucratus/gymnocephalus	B	BH	D	W
Helichrysum scorpioides	B	BH	D	
**Hypochaeris radicata*	B	BH	D	W
Lagenifera stipitata	B	BH	D	W
Ozothamnus rosmarinifolius	B		D	
Senecio cf. *glomeratus*			D	

Senecio sp. E	B			
**Taraxacum officinale*	B			
Campanulaceae				
Wahlenbergia ceracea	B		D	
Caryophyllaceae				
Stellaria angustifolia			D	
S. pungens	B			
Clusiaceae				
Hypericum japonicum	B	BH	D	W
Convolvulaceae				
Dichondra repens	B	BH	D	W
Droseraceae				
Drosera binata	B			
Epacridaceae				
Epacris breviflora	B			
E. microphylla var. *rhombifolia*[2]				
E. paludosus	B	BH	D	W
E. pulchella	B			
Leucopogon pilifer	B			
Fabaceae – Faboideae				
Pultenea polifolia	B			W
**Trifolium repens*			D	
Fabaceae – Mimosoideae				
Acacia melanoxylon (edge of swamp)				W
Gentianaceae				
Chionogentias cunninghamii subsp. *cunninghamii* [formerly *Gentianella diemensis* s. lat.]	B			
Geraniaceae				
Geranium neglectum	B	BH	D	W
Goodeniaceae				
Velleia montana	B	BH		
Haloragaceae				
Gonocarpus micranthus subsp. *micranthus*	B	BH	D	W
Myriophyllum pedunculatum subsp. *pedunculatum*	B	BH	D	W
Lentibulariaceae				
Utricularia dichotoma	B			W
Lobeliaceae				
Pratia surrepens	B	BH		W
Loganiaceae				
Mitrasacme serpyllifolia		BH		
M. sp. aff. *serpyllifolia*		BH		
Myrtaceae				
Baeckea utilis	B	BH	D	W
Callistemon pityoides	B		D	W
Eucalyptus macarthurii[3]				
E. pauciflora	B			W
Leptospermum grandifolium			D	W
L. myrtifolium	B	BH	D	W
L. obovatum	B	BH	D	
Onagraceae				
Epilobium gunnianum	B	BH	D	W

Polygalaceae				
Comesperma retusum	B	BH		W
Proteaceae				
Banksia marginata	B			
Hakea microcarpa	B	BH	D	W
Ranunculaceae				
Ranunculus papulentus	B	BH	D	W
R. pimpinellifolius	B		D	W
Rosaceae				
Acaena novae-zelandiae	B			
Rubiaceae				
Asperula cf. *gunnii*	B	BH	D	W
Nertera granadensis	B			
Rutaceae				
Boronia deanei	B			
Scrophulariaceae				
Gratiola peruviana	B	BH	D	W
Veronica calycina	B			
Stylidiaceae				
Stylidium graminifolium	B	BH	D	W
Violaceae				
Viola hederacea (edge of swamp)				W

MONOCOTS

Anthericaceae				
Arthropodium milleflorum	B	BH	D	W
Cyperaceae				
Baumea gunnii[2]				
Baumea sp.			D	
Carex appressa	B	BH	D	W
C. gaudichaudiana	B		D	
Eleocharis gracilis				W
Isolepis crassiuscula	B	BH		W
I. habra	B			
I. subtilissima	B			
Gahnia aspera	B			
Lepidosperma filiforme	B		D	W
Scirpus polystachyos[4]				
Juncaceae				
Juncus fockei[2]			D	
J. planifolius	B		D	W
J. sandwithii				W
J. sarophorus		BH		
Luzula ?modesta	B	BH		
L. ovata[5]				
Hypoxidaceae				
Hypoxis hygrometrica var. *hygrometrica*	B	BH		
Iridaceae				
Patersonia fragilis	B			W
Orchidaceae				
Eriochilus cucullatus		BH		
Genoplesium rufum				W
Prasophyllum rogersii	B			
Pterostylis furcata	B			

Spiranthes sinensis subsp. *australis*	B	BH	D	W
Thelymitra sp.	B	BH		W
Poaceae				
Agrostis sp. A	B	BH		
Amphipogon strictus[6]				
Danthonia laevis		BH		
Deyeuxia brachyantha	B			
D. gunniana	B	BH	D	W
D. quadriseta			D	
Dichelachne inaequiglumis	B		D	
**Glyceria declinata*		BH		
Poa labillardieri	B			
Restionaceae				
Empodisma minus	B	BH	D	
Restio australis[7]	B	BH	D	W
R. longipes[7]		BH		
Xyridaceae				
Xyris ustulata	B	BH	D	W
X. ?ustulata (small flower-heads)	B			

* introduced taxa naturalised.

[1] two forms of *Hydrocotyle peduncularis* recorded. Form A has small, shallowly lobed, light green leaves. Form B has larger leaves and inflorescences, the leaves also being more deeply dissected/lobed and a darker green. Requires further investigation.

[2] Jensens Swamp (Benson & Keith specimen in NSW herbarium collection).

[3] Roly Whalans Swamp, beside swampy creek (L.A.S. Johnson specimen in NSW herbarium collection).

[4] collected from swamp on west side of Kowmung River Fire Trail, c. 2 km S of junction with Kanangra Road.

[5] Roly Whalans Swamp, edge of *Sphagnum* swamp (K.L. Wilson specimen in NSW herbarium collection).

[6] recorded from more open areas on swamp margins by Keith & Benson (1988, p. 134).

[7] these species will be transferred to the genus *Baloskion* (B.G. Briggs, pers. comm.).

Other species

Black (1982) recorded the following species occurring in Boyd River and/or Jensens Swamps: *Blechnum penamarina*, *Pimelea linifolia*, **Trifolium dubium*, *Leucopogon ericoides*, *Cassinia quiquefaria*, *Lepyrodia scariosa*, *Schoenus apogon*, *Lepidosperma tortuosum*, *Poa sieberana* and *Danthonia pallida*. These have not been varified by the authors.

Table 2. Species of particular conservation significance or interest.

Boronia deanei	3VCa = vulnerable species with geographic distribution range 100+ km, adequately reserved (Briggs & Leigh 1988)
Eucalyptus macarthurii	2RCi = rare species with geographic distribution range < 100 km, inadequately reserved (Briggs & Leigh 1988); outlying population and northern limit of distribution
Leucopogon pilifer	First record for Central Tablelands Botanical Division. Previously known from the Northern and Southern Tablelands of New South Wales, and Victoria and Tasmania
Prasophyllum rogersii	First record for Central Tablelands. Previously recorded only from the Barrington Tops area, New South Wales, and northern Victoria
Restio longipes	2VC- (Briggs & Leigh 1988), the distribution range now known to extend over 100 km, therefore should be coded 3VC-; only known from a few localities on the Central Tablelands and the Clyde Mountain district of the Southern Tablelands
Wahlenbergia ceracea	Local disjunct population on Boyd Plateau (Keith & Benson 1988)

Conclusion

About 100 native species of Angiosperms have been recorded from the Boyd Plateau swamps, including several rare species (Table 2). Further surveys undertaken at different times of the year and at other wetlands on the plateau are likely to extend this species list. Although the important regional significance of the Boyd Plateau swamps in relation to other upland swamps was discussed generally by Keith & Benson (1988) these results and the findings from other wetland studies lend themselves to further comparative investigation.

Acknowledgements

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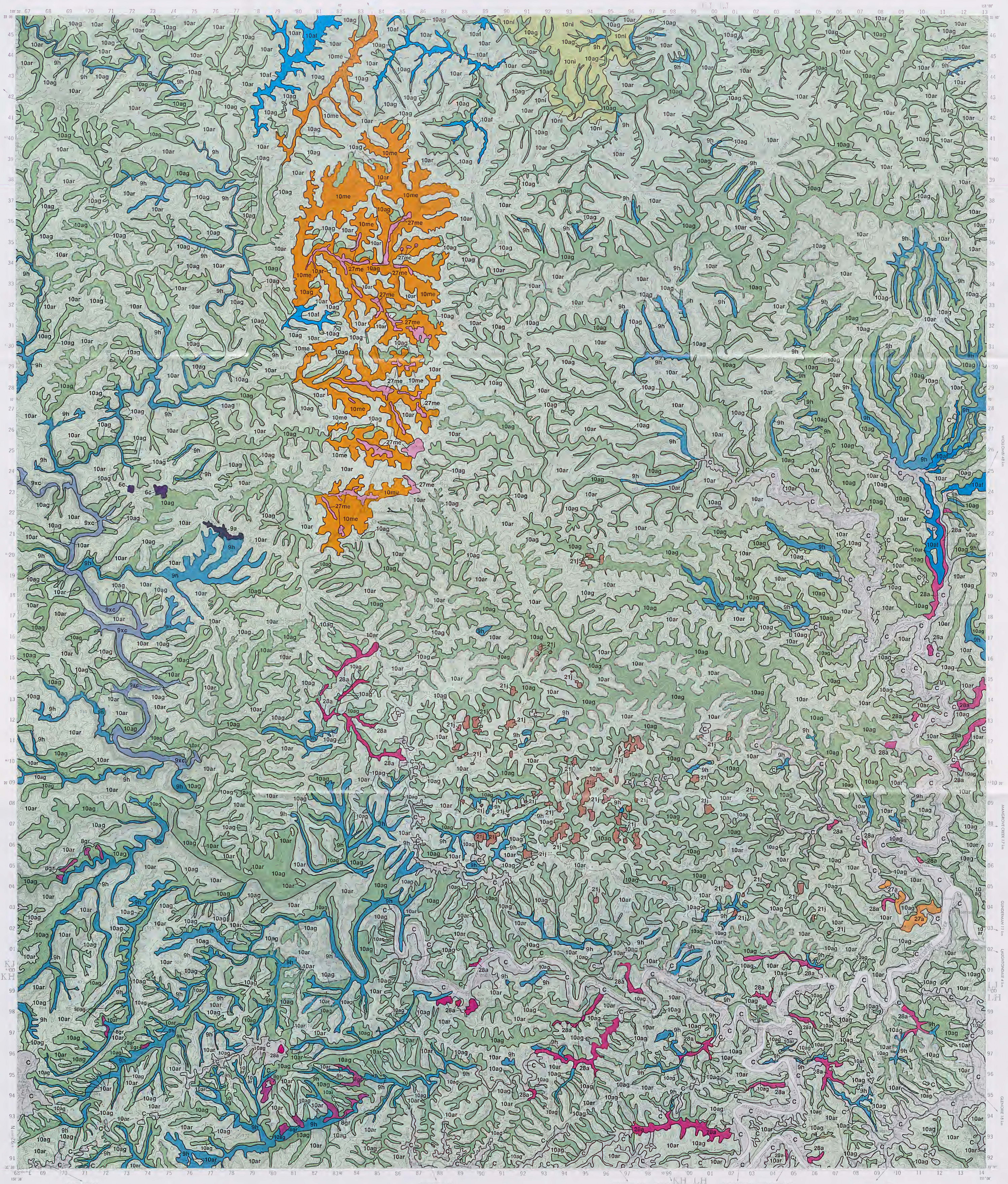
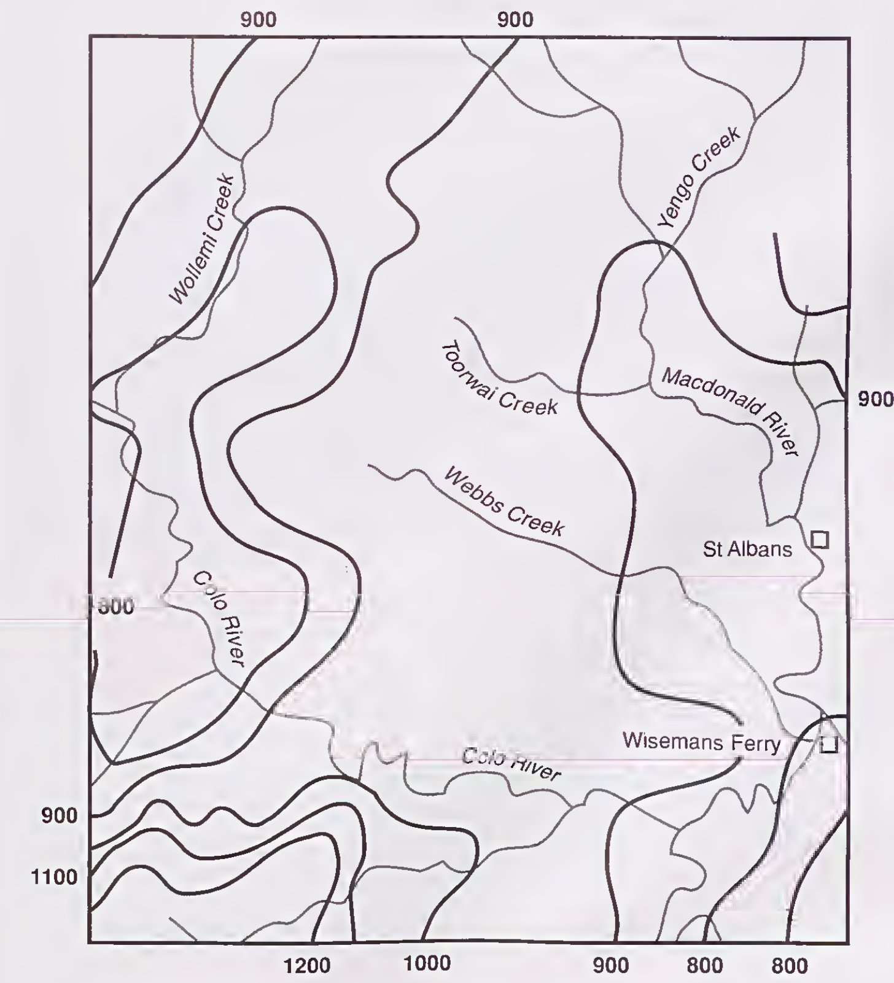
ST ALBANS

1:100 000 VEGETATION SERIES



MAP UNIT DESCRIPTIONS

Map Unit	Structure	Main Canopy Species	Geology	Occurrence
6c	**Glen Forest**			
	Tall open-forest	*Eucalyptus saligna* *Eucalyptus paniculata*	Tertiary volcanics	Isolated outcrops e.g. Culoul Range
8gr	**Gully Rainforest**			
	Closed-forest	*Doryphora sassafras* *Ceratopetalum apetalum* *Acmena smithii* *Backhousia myrtifolia* *Schizomeria ovata*	Enriched aluvium	Deep gullies, Wheeny Creek, Colo Gorge
[illegible]	**Shale Cap Forest**			
	Open-forest	*Eucalyptus paniculata* *Eucalyptus crebra* *Syncarpia glomulifera*	Wianamatta Shale	Cappings on ridgetops, lower rainfall e.g. Putty Road
	Tall open-forest	*Eucalyptus deanei* *Eucalyptus cypellocarpa* *Syncarpia glomulifera*		Higher rainfall, Mountain Lagoon
9h	**Hawkesbury-Narrabeen Sheltered Forest**			
	Tall open-forest / Open-forest	*Eucalyptus deanei* *Eucalyptus saligna* *Syncarpia glomulifera* *Angophora floribunda*	Hawkesbury Sandstone, Narrabeen Group	Lower slopes, sheltered gullies, Colo and Hawkesbury Rivers
9xc	**Colo Gorge Forest**			
	Open-forest	*Eucalyptus deanei* *Eucalyptus saligna* *Eucalyptus elata*	Floodplain alluvium	River-flats, below Upper Colo
	Woodland / Open-forest	*Eucalyptus agglomerata* *Angophora floribunda* *Syncarpia glomulifera* *Eucalyptus deanei*	Narrabeen Group, alluvium	Upper Colo River, Wollemi Creek
	Closed-forest	*Ceratopetalum apetalum* *Tristaniopsis laurina* *Acmena smithii*		
	Closed-forest	*Casuarina cunninghamiana* *Tristaniopsis laurina* *Leptospermum polygalifolium*		
10af	**Rough-barked Apple Woodland**			
	Woodland	*Angophora floribunda* *Eucalyptus tereticornis* *Eucalyptus amplifolia*	Quaternary allivium	Valley flats and creek lines
10ag	**Sydney Sandstone Gully Forest**			
	Open-forest	*Angophora costata* *Eucalyptus piperita* *Eucalyptus agglomerata* *Syncarpia glomulifera*	Hawkesbury Sandstone, Narrabeen Group	Sheltered slopes and gullies
10ar	**Sydney Sandstone Ridgetop Woodland**			
	Low open-woodland / Woodland	*Corymbia eximia* *Angophora bakeri* *Corymbia gummifera* *Angophora costata* *Eucalyptus punctata*	Triassic Hawkesbury and Narrabeen Group sandstone	Exposed slopes and ridges
	Heath / Scrub / Woodland	*Calytrix tetragona* *Darwinia fascicularis* subsp. *oligantha* *Eucalyptus haemastoma* *Eucalyptus squamosa* *Corymbia gummifera*	Tertiary sand, gravel	Maroota Sandmass Complex
	Open-forest	*Eucalyptus pilularis* *Angophora costata*	Mittagong Formation	Wheelbarrow Ridge
10me	**Mellong Woodlands**			
	Woodland	*Eucalyptus sclerophylla* *Angophora bakeri*	Quaternary allivium	Mellong Plateau, well-drained sites
	Woodland	*Eucalyptus parramattensis*		Poorly-drained sites
10ni	**Narrabeen-Hawkesbury Ironbark Woodland**			
	Woodland	*Corymbia eximia* *Eucalyptus fibrosa* *Eucalyptus crebra* *Eucalyptus beyeriana*	Narrabeen Group sandstone, shale lenses	Slopes and ridges with localised clay soils
21j	**Dwarf Apple Scrub**			
	Open-forest	*Angophora hispida*	Hawkesbury Sandstone	Ridges and exposed slopes north of Wheelbarrow Ridge
27a	**Estuarine Complex**			
	Low Open-forest	*Casuarina glauca*	Quaternary alluvium	Floodplain, Webbs Creek
	Closed-scrub	*Melaleuca ericifolia*		Hawkesbury River below Wisemans Ferry
27me	**Mellong Swamps**			
	Sedgeland	*Lepyrodia scariosa* *Schoenus brevifolius*	Quaternary alluvium	Mellong Plateau, waterlogged soils
28a	**Freshwater Reed Swamps**			
	Open-sedgeland	*Eleocharis sphacelata* *Juncus usitatus* *Persicaria hydropiper*	Quaternary alluvium	Lower Colo, Macdonald and Hawkesbury Rivers
	Tall Scrubland	*Melaleuca linariifolia*		Creekflats
	Sedgeland	*Lepidosperma longitudinale* *Melaleuca linariifolia*		Mountain Lagoon
C	**Cleared**	Cleared areas are generally those sites with the better agricultural soils such as the riverflats or shale and basalt cappings		



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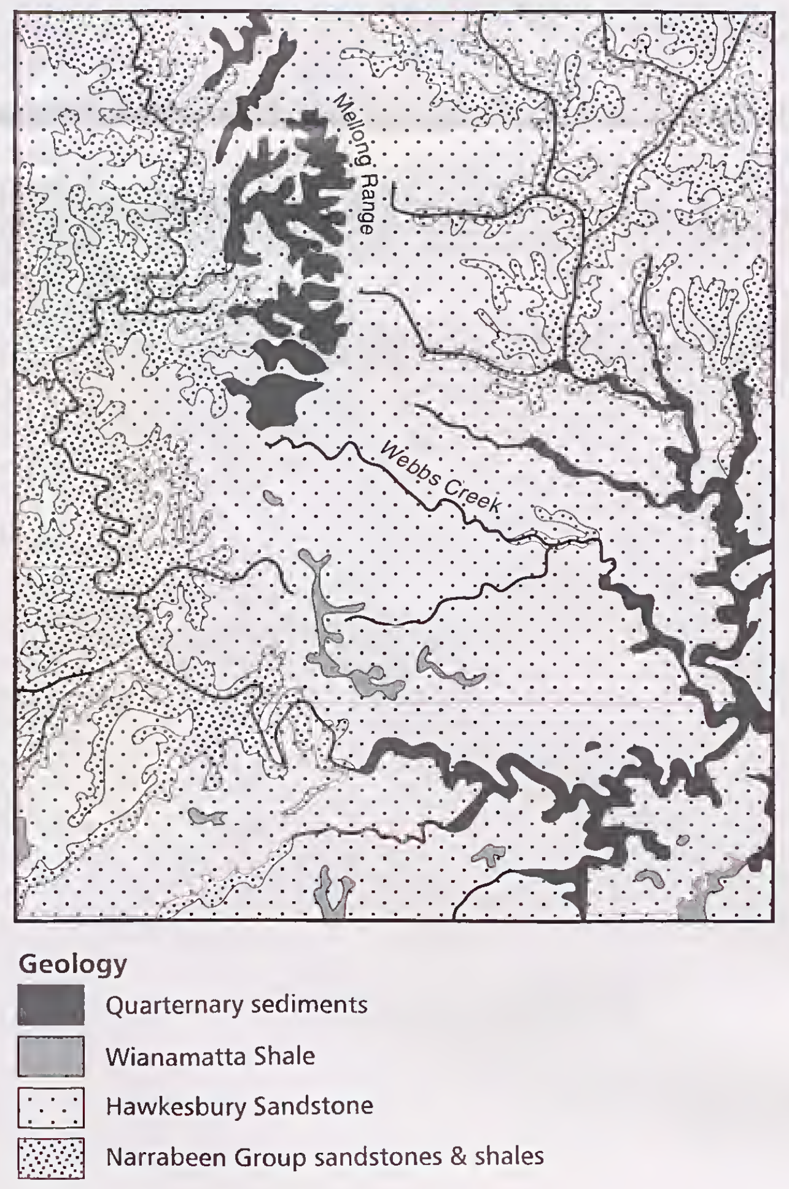
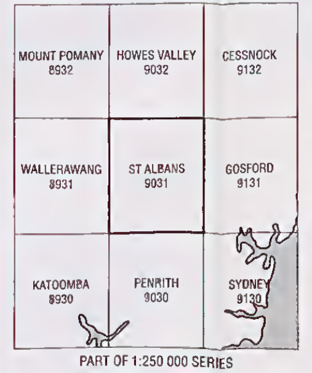
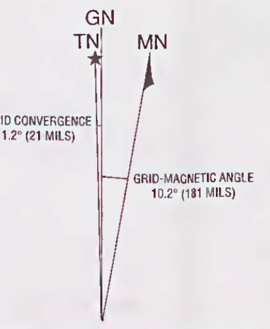


INDEX TO ADJOINING MAPS



PART OF 1:250 000 SERIES
SI 56-5 SYDNEY


GN
TN
MN
GRID CONVERGENCE 1.2° (21 MILS)
GRID-MAGNETIC ANGLE 10.2° (181 MILS)

TRUE NORTH, GRID NORTH AND MAGNETIC NORTH ARE SHOWN DIAGRAMMATICALLY FOR THE CENTRE OF THIS MAP. MAGNETIC NORTH IS CORRECT FOR 1975 AND MOVES EASTERLY BY 0.1° (2 MILS) IN ABOUT THREE YEARS.

SCALE 1:100 000
2 0 2 4 6 8 10
KILOMETRES

NUMBERED GRID LINES ARE 1 000 METRE INTERVALS OF THE AUSTRALIAN MAP GRID, ZONE 56
GRID VALUES ARE SHOWN IN FULL ONLY AT THE WEST CORNER OF THE MAP
HORIZONTAL DATUM: AUSTRALIAN GEODETIC DATUM 1966
VERTICAL DATUM: AUSTRALIAN HEIGHT DATUM
TRANSVERS MERCATOR PROJECTION
CONTOUR INTERVAL 20 METRES
ELEVATIONS IN METRES

NATURAL VEGETATION
# of the
ST ALBANS AREA

Kate Ryan, Mark Fisher & Liza Schaeper

Detailed descriptions of the plant communities are given in
CUNNINGHAMIA Volume 4, Number 3, 1996
Compiled and prepared at the
NATIONAL HERBARIUM OF NEW SOUTH WALES

ROYAL BOTANIC GARDENS SYDNEY

1996

Understanding the ecology of our native plants

Cunninghamia

A journal of plant ecology

Volume 4(3): 433–530 1996

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